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## THE USE OF NUMBERS IN MEASUREMENT.

BY ERNEST B. SKINNER,
*The University of Wisconsin.*

If any progress is to be made in the matter of applying mathematics to physics, the matter of measurement must be taken up in the algebra. Accurate knowledge of the physical universe must come through measurement of its phenomena. Anything is measurable which presents itself to our senses in varying degrees of strength, as weight, light, pitch of tone, tone intensity, strength of current of electricity, velocity. Unaided, the senses record only relative measurements and that only when considerable differences exist. For example, few people could distinguish between two weights of five pounds and five pounds and one ounce, respectively, and not many could guess within a half pound of the weight of a mass weighing five pounds. Accurate measurement is possible only with the help of an appropriate measuring instrument as a clock or a yard stick, or a weighing scale.

Algebra deals for the most part with pure number which is wholly a creation of the mind and is independent of the external world. How then can pure number be brought to assist us in weighing and measuring the physical universe? It is not necessary for the teacher to go into a long philosophical discussion concerning the nature of measurement, nor even to undertake to state that the measurement of all physical quantities may be referred in the last analysis to the measurement of three which may most conveniently be taken as length, time, and mass; but it is important that the pupils know, roughly speaking at least, what is meant by measurement.

All magnitudes are measured by comparing them with a standard magnitude, the unit, which is of the same kind. A length is measured by comparing it with a unit length, a mass with a unit mass, a velocity with a unit velocity. The unit is in all

cases arbitrarily chosen, though it should be conveniently chosen. It would not be convenient for us to buy coal by the pennyweight nor diamonds by the ton.

Numbers are applicable to measurement since, in the first instance, they serve as counters for the number of times the magnitude contains the unit. If, for example, a foot rule may be applied to a line exactly six times without any two positions of the rule overlapping and without leaving any portions which do not come under the ruler, we say that the length of the line is six feet, or, more accurately, that the measure of its length is the number six when the unit is the foot. The measure but not the length would change if we use the inch as the unit. Indeed, we may express this change in measure in equational form by writing 6 feet = 72 inches = 2 yards = 12 half feet. If the unit is not contained an exact number of times we must resort to some other plan. In such cases it is possible that a half foot or a quarter foot or some other fraction of the foot is contained an integral number of times. If the length should contain a quarter foot 25 times we would say that the length is $6\frac{1}{4}$ feet and that the measure is $6\frac{1}{4}$ or $^{25}/_{4}$. In equational form one has

$$\frac{\text{given length}}{\text{one foot}} = \frac{25}{4}.$$

The ratio of the given length to the unit is the same as 25 to 4, i. e., the ratio of two integers and these integers are the measure of the length and the unit in terms of the new measure, a quarter of a foot, the two lengths have the same ratio as their measures. If we could measure the length in 64ths of a foot we should again have its measure expressed as the quotient to two integers. In general we say that if the ratio of two magnitudes can be expressed as the ratio of two integers they are commensurable with each other.

But it may happen that we have a magnitude such that no part of the unit of measure, however small, is contained in it an integral number of times. Of such a magnitude we say it is *incommensurable with the unit*. The existence of such magnitudes can never be made evident to the senses even with the aid of the most refined measuring instruments. Indeed, incommensurability is only relative and has no meaning except when the magnitude of one quantity is considered in its relation to another. Every magnitude is commensurable provided only the proper magnitude is chosen as the unit. For example, any mag-

nitude is commensurable with any aliquot part of itself taken as a unit, say the half or the third. Strictly speaking we ought then to speak, not of incommensurable magnitudes, but of incommensurable ratios.

An incommensurable ratio always gives rise to an irrational number. In other words the measure of the measure of a magnitude that is incommensurable with the unit is an irrational number like $\sqrt{3}$, $\sqrt[3]{2}$, or $\pi$.

For practical purposes incommensurable magnitudes are never used. For example, a carpenter would report the length of a board in feet, inches, and half, quarter, eighth, or sixteenth inches, which means nothing more than that the measure expressed in feet would be an ordinary fraction, proper or improper, i. e., the quotient of two integers. However closely they may weigh or measure, the physicist and the chemist invariably express their results in quotients of integers or in some fashion which amounts to the same thing, i. e., in *rational* numbers, which are more or less close approximations to the measures of the magnitudes in question.

But if incommensurable quantities are never used in practical work they are exceedingly common in theory. A single example will suffice. If we assume again the truth of the Pythagorean theorem, we see that the measure of the diagonal of a square, each side of which is one foot, comes out to be $\sqrt{2}$ feet, if indeed this expression can have any meaning. We seem to have

$$\frac{\text{length of diagonal}}{\text{length of side}} \quad \frac{\sqrt{2}}{1} = \sqrt{2}.$$

But $\sqrt{2}$ cannot be the quotient of two integers as one may easily prove.

This is precisely the thing that will make difficulty when the class comes to the incommensurable cases in geometry.

It would be worth while to recall the definition of unit time to give the definition of unit mass, which will be new to the class, to define velocity, and to indicate how one may reach the notion of unit velocity. Farther than this it would scarcely be possible to go though this much is not at all adequate to the needs of those teachers who would bring in all sorts of physical problems to illustrate and to make clear the algebra.*

*For the teacher who can read German an excellent discussion of this topic is available in the *Encyklopadie der Elementar-Mathematik* by Weber and Wellstein, *Funfter Abschnitt*.

One of the most important things for the teacher to note in connection with the use of numbers in measurement is the degree of approximation that should be obtained in a given case. Practical mathematics prepares results for the artisan, for the machinist, for the student who is experimenting with matter, and these results must be left in the most convenient form for the worker who is to use them. The carpenter must take account of tenths of an inch but ordinarily a hundredth of an inch is to him a negligible quantity, while a thousandth of an inch is far from negligible to the metal worker. The skilled laboratory worker may need the fourth decimal place but it is only in the rarest instances that use can be made of the fifth and sixth decimal places. A little care and attention to the nature of the problem in hand will enable the pupil to judge the degree of accuracy required.

It must not be forgotten, however, that the last figure obtained in an approximation process even though it is correct may not be the best one to use. A well-known example is that of the approximate value of $\pi$. The correct figure in the fourth decimal place is 5 but we always use the approximation 3.1416 when we use four decimal places and properly so since the next figure is 9 so that 3.1416 is a much better approximation than 3.1415.

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## HIGH SCHOOL CONFERENCE AT THE UNIVERSITY OF ILLINOIS.

The 1910 session of the Annual High School Conference held at the University of Illinois will occur on November 17, 18, and 19. Thursday evening there will be the usual round-table session. Throughout the day on Friday the section meetings will be in session. These now include all departments of high school work. Friday evening the address will be by Professor E. C. Elliott of Wisconsin University.

The chief purpose of these conferences is to give the high schools a chance to express their views and wishes in regard to all matters lying along the line of contact between the high schools and the University. The success of the plan depends chiefly on the presence of a good representative body of high school teachers and principals. Last year about six hundred were present.

It is especially important at this time that teachers of vocational subjects, such as agriculture, domestic science, manual arts, and commercial subjects should be present in order that the most satisfactory basis possible for the accrediting of these subjects may be found.

# SECOND REPORT OF COMMITTEE OF MATHEMATICS SECTION OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS ON REAL APPLIED PROBLEMS IN ALGEBRA AND GEOMETRY.

## Summary of First Report.

This committee, created at the annual meeting in November, 1908, presented a preliminary report at the meeting in Chicago, November, 1909. The preliminary report, based upon a year's investigation by the Committee, set forth the theory underlying the real problem movement in secondary mathematics, gave an account of the preliminary investigation regarding the various fields in which direct applications of elementary algebra and geometry are encountered, included a collection of problems made during the year and printed from month to month in SCHOOL SCIENCE AND MATHEMATICS, and suggested a list of books and magazines on practical subjects which are sources of applied problems in algebra and geometry, and which may be consulted in search for problem material.

In the discussion of the theory underlying the real problem movement, it was pointed out that the movement aims to reform the teaching of elementary algebra and geometry by teaching the subjects more in relation to their practical uses. The subjects are to be looked at by the student, not as mere pure sciences to be studied solely for the purposes of mental discipline, but rather as scientific instruments in doing the world's work. Mental development is not to be minimized at all, but the functional or application side of the subjects is to be given its due emphasis. The report defended this emphasis, upon psychological grounds. It showed the value of the direct applications of algebra and geometry in practical life and in the motivation or development of interest in the subjects. And it showed the necessity of their uses in the school in assisting the individual's knowledge of the subjects to function, thus supplying the final step in the educative process.

By the problems collected and printed in SCHOOL SCIENCE AND MATHEMATICS, it was demonstrated conclusively that elementary algebra and geometry do have numerous direct applications in a great variety of fields. To collect a fund of these problems for school use is only a matter of time and coöperative effort on the part of a large number of people.

### Scope of Investigation.

As pointed out in the first report, the investigation has two phases; viz., (1) the determination of the extent to which algebra and geometry do have direct practical application in the world about us, and the collection and editing of a fund of such problems of application; and (2) the determination of the adaptability of the problems collected for use in secondary schools, it being assumed that many of the problems that might be collected are too technical or too difficult to be comprehended by the average high school pupil.

The work of the committee the first year was devoted entirely to the first phase of the investigation. During the past year the work of collecting and editing problems has been continued. From three to four pages of applied problems, collected and contributed by teachers in different places and by members of the committee, have been printed each month in SCHOOL SCIENCE AND MATHEMATICS, as was done the year before.

During the past year the attempt has been made to have the problems that have been collected and printed tried out in a large number of good schools in different parts of the country, with a view to determining in a scientific way their adaptability to the comprehension and interests of boys and girls in secondary schools.

### Problems Printed.

The new problems printed in SCHOOL SCIENCE AND MATHEMATICS since last November are submitted as an integral part of this report.

An examination of the problems printed in SCHOOL SCIENCE AND MATHEMATICS by the committee in the last two years reveals the fact that they occur in a great variety of fields of application, as follows: Agriculture, athletics, architecture, brick and masonry construction, bridge building, various phases of business, carpentry, civil engineering, design, dietetics, drafting, embroidery, forestry, games, geography, use of instruments for measuring and construction, different phases of manufacturing, machinery, different phases of practical mechanics, mining, practical mensuration (unclassified), navigation, pattern making, plumbing, railroad work, science, sheet metal work, and steel construction. The fields in which the greatest number of problems have been collected are civil engineering, carpentry, architecture,

machinery and various phases of applied mechanics, design, sheet metal work, science, agriculture, and the use of instruments for measuring and construction. This is probably largely accidental. An exhaustive search probably would reveal other fields as rich in the applications of algebra and geometry. It must be conceded that the work as yet done along the line of collecting real applied problems is a mere scratching on the surface, and can serve only as an index to the great possibilities in the real problem movement if it is carried on thoroughly by the great body of teachers and text-book writers for a number of years.

An examination of these problems shows also that they illustrate a large part of the subject matter of elementary algebra and geometry. In algebra they are distributed as follows: linear equations in one unknown number, 25; systems of linear equations, 6; quadratic equations, 4; formulæ solved as equations, 10; formulæ used for computation, 11; advance topics, 8. In geometry they are distributed by books as follows: Book I, 17; Book II, 29; Book III, 30; Book IV, 18; Book V, 29; Book VII, 27; Book VIII, 11.

**Adaptability of Problems.**

At the request of the Mathematics Section when the first report was submitted, the problems printed in SCHOOL SCIENCE AND MATHEMATICS up to November, 1909, were rearranged and classified according to the topics of algebra or the books of geometry which they illustrated, and reprinted in pamphlet form for class room use. Nearly three thousand copies of this problem pamphlet have been requested by teachers since the middle of the last school year. A few copies still are available.

During the year a circular was sent out to a large number of schools where this problem pamphlet was being used, asking those schools to be prepared to make a report to the committee at the end of the school year regarding the adaptability of such problems as were tried in one or more classes to the interests and capacities of the students. It was requested that the following points be covered in the reports:

1. In what grades were the problems used?
2. What problems tried do you think too difficult for the classes in which used? Are they more difficult than the corresponding problems of the text-book?
3. Were the problems of algebra more or less difficult than those of geometry? What types?
4. Do boys or girls find the problems more difficult?
5. How much explanation by the teacher of the meanings of the problems was necessary?

6. Do pupils show more interest in these problems than in the abstract or artificial ones?

7. In what kinds of problems, in what fields of application, do pupils show most interest?

8. Do boys or girls show the greater interest in these problems?

9. Encourage pupils to bring in real problems of local application in the manual training work, etc. What success along this line?

10. Other points, not here covered, that you have observed in the use of the problems. Write the committee any general suggestions that you have to make as the result of your experience, or on general grounds.

Unfortunately, the problem pamphlet did not get distributed to teachers in time for use in classes the first half of the school year. Consequently, not many schools were able to make an extensive use of the problems. In many cases, local conditions prevented a thorough trial of the problems in the class room. As a result, the reports from many schools were apologetic in nature, the teachers expressing the hope of being able to use the problems in a more systematic way during the coming school year. Instead of fifty, as we had hoped, only fifteen schools, representing the experiences of about thirty-five teachers, were in a position to make comprehensive reports, covering practically all of the above points. Several other schools sent incomplete statements, or general expressions of commendation or criticism of the problems, based upon their slight use of them. Hence the expectations of the committee of being able to report at this meeting, in a thorough scientific fashion, regarding the adaptability of the problems collected, have been only partly realized.

The summaries of the reports of the fifteen schools giving the problems the most careful trial are here submitted, in the belief that in as far as they go, they will be found to furnish an approximately accurate estimate of the value of the problems printed by the committee during the first year of the investigation.

In some schools only the geometry problems were used. In some cases the problems were used largely in reviews. But in most cases they were taken along with the regular work of the classes.

In the following summary the numbers correspond to the numbers of the questions or topics in the circular sent to the teachers:

1. A few problems were used in first year classes, and some in fourth year classes; but in the great majority of cases they were used in second and third year classes.

2. Problems 58, 60, 63, 66, 70, and 71 only were reported

as too difficult for the classes in which they were tried by one or more schools. It must be remembered that some problems were tried in only a few schools. Some teachers omitted purposely the problems they judged would be found too difficult for their classes. Consequently, this list of the problems that are too difficult for secondary schools probably should be somewhat extended.

One-third of the schools found the problems, on the average, not more difficult than the corresponding problems of text-books. Two schools thought that the pupils found them easier, because of the greater interest they aroused. The rest of the schools judged that their pupils found the applied problems, on the average, slightly more difficult than those in the text-books.

It is evident that a small portion of the problems printed must be discarded as too difficult for use at any place in the high school course. A more thorough trial with classes would be necessary to determine just what individual problems should be eliminated on the ground that they are too difficult. This sifting process, as applied to all of the real problems now collected or that will be collected in the future, as this movement progresses, will come as the results of the extended experiences of teachers in dealing with such problems.

3. No important conclusion can be reached in answer to question 3. Some schools used only the geometry problems, and hence had no basis for comparison. Two schools reported the algebra problems the less difficult, but the majority found no difference in the difficultness of the problems in algebra and geometry.

4. It was the experience of six schools that girls found the problems more difficult than boys did. The other schools could detect no difference in the capacities of girls and boys in solving the problems.

As suggested by two or three teachers, the majority of the problems touched more nearly upon the experiences of boys than those of girls. They had more meaning to boys than to girls. This fact would probably account for the experiences of those teachers who reported that the problems were found more difficult by girls than by boys.

5. The amount of explanation of the meanings of the problems on the part of the teachers was reported by schools as follows: "Considerable. Might have been greatly reduced after considerable experience with such problems;" "Little;" "Little,

if any more than book problems;" "Too technical problems were avoided;" "Little or none on those used;" "In some cases;" "Little;" "None;" "Considerable at times;" "Little with those tried;" "Very little;" "Considerable for second year students;" "Some explanation with a few problems;" "Very little."

While it must be remembered that some teachers purposely avoided using those problems that in their judgment were too technical for their pupils, it is safe to conclude from these reports that the great majority of the problems that have been printed are not too technical or too far removed from the experiences of the average boy or girl to be used in ordinary secondary schools. In some cases real problems that may be found expressed in language too technical to be understood by the average boy or girl may easily be made intelligible by rewording them in nontechnical language, or when possible, illuminating them by pictures of the things involved. This does not detract at all from the reality of the problems. In fact, the most real of problems encountered in life are those found involved in situations, and not formulated in language at all.

Just which ones of the problems printed by the committee refer to things too far removed from the experiences of the average boy or girl, or which ones need to be reworded in nontechnical language, is a matter to be determined by the extensive experiences of teachers in the future.

6. All schools but two testified to the greatly increased interest of the pupils in these applied problems over the problems of the text-books.

The report from Portland, Oregon, says: "While I have had this work only twice before, I have found such a vast difference in the interest displayed this term that I am heartily in favor of such problems."

The report from Central High School, Toledo, Ohio, says: "At the end of the semester, I asked for written opinions about the work. Most pupils thought the concrete problems were easier than the abstract ones of the text. A few girls thought them difficult but nevertheless more interesting."

The report from Gary, Ind., says: "Pupils show very much more interest in these problems than in the abstract or artificial ones."

The report from Oakland, Cal., says: "In reply to the question, 'Do pupils show more interest in these problems than in the abstract or artificial ones?' Yes. Are enthusiastic."

Of the schools that tried some of the problems and made incomplete reports, not included among the fifteen summarized here, all commended the problems tried as possessing greater interest to the pupils than the problems in the text-books.

At one school the parents of some of the pupils, who were mechanics or carpenters, became interested in the problems.

We have found, therefore, that this one of the main arguments in favor of the use of real applied problems of algebra and geometry in the school room, which has been advanced on theoretical grounds, is being substantially supported by the experiences of those who have made actual use of the problems in teaching. This is a matter of the greatest interest to those who are following the real problem movement.

7. No reliable record as to what kinds of problems pupils are most interested in has been obtained. One report says that there was greater interest in manual training problems, and problems connected with business. Another says that the greatest interest was shown in problems in forestry, architecture, and physics. Still another found the greatest interest in those problems of geometry involving constructions, and in the problems in architecture and designing. Others, not differentiating as to special fields of application, reported the general conclusion, which one would deduce on theoretical grounds, that those problems proved of greatest interest that touched in some way the pupil's immediate life. This suggests, of course, the desirability of finding problems of local application in each school community and problems actually encountered in the work of different individual pupils in and out of school, a matter discussed at another point in this report.

8. Four schools did not give answers to question 8: "Do boys or girls show the greater interest in these problems?"

Seven schools reported that boys showed the greater interest; three reported that girls and boys showed equal interest; and one reported that girls showed the greater interest, which was in a single class where there were only a few boys.

The greater interest thus shown by boys can be accounted for by the fact that the problems enter more extensively into the experiences of boys than of girls. The need for more problems that relate to the experiences of girls is evident. The experience of the committee has been that such problems are more difficult to find than those that relate to the experiences of boys.

9. Of the fifteen schools reporting, five have attained some degree of success in having pupils bring in, or propose, problems of local interest that are either suggested by the problems printed by the committee in the problem pamphlet used by the class, or encountered by some pupil in his work in other lines in or out of school. This is very gratifying.

Miss Sarah Ruby, Portland, Ore., says: "Problem 42 suggested various forms of trefoils and quadrifoils which they had observed in church windows and elsewhere. I found them so interested in these and various designs of parquet floors that I asked them to keep a notebook for them. When their notebooks were handed in I found as many as seventy designs in several books. At the time of the equinox, some of the classes who were studying physical geography suggested the problem of finding the latitude of Portland by means of the shortest shadow of an object. Following this, I had them look up Eratosthenes and gave them a few facts from which they worked out Eratosthenes's method of measuring the circumference of the earth. When studying the theorems of equal triangles, I told them that Thales was thought to have measured the distance of a vessel at sea by means of one of them, and left them to tell how it might be done. They at once suggested their use for timber cruising, * * * and one boy, who had observed the method used at the aërial navigation meet for finding the height of the airship, suggested that application. * * * Some of the problems proposed, such as * * * finding the width of Mt. Hood at the snow line (a girl asked about this), we have left for the work in similar triangles."

Mr. S. F. Beard, Bradford, O., says: "I have encouraged pupils to bring to the school room simple machines, and then with due study and measurement, to lay off their designs on paper. In other cases sketches have been made by the pupils, and these have been studied in class. The materials for this work have been found in the home, on the farm, in the carpenter's shop or blacksmith's shop, when bridges have been built, now and then from the railroad, or from whatever source may be at hand. For me there have been many surprises at the sources from which pupils themselves draw many problems. * * * No. 38 was caught by a girl, and readily solved, with an accurate drawing. A catalogue from a manufacturer of manual training tools was used freely in making original real applied problems of this kind. * * * No. 42 awakened quite

a field in trefoils and quadrifoils. The pupils enjoyed finding these figures in windows, gables, and even originated many. * * * In addition, designs from wall paper, oilcloth, parquetry, linoleums, steel ceilings, etc., were passed in review. * * * This was indeed a fertile field for us."

Miss Marie Gugle, Toledo, O., says: "Just a few pupils have used their geometry in their outside experiences. A summary of these is as follows:

"(1) Used much in manual training department, especially in pattern making.

"(2) In athletics, in laying out baseball diamond and measuring distances with short tapes and from several angles.

"(3) Several have helped their fathers who are carpenters or other kinds of mechanics.

"(4) In making pennants and in lettering. One boy does quite an extensive business in making and selling pennants; and he, perhaps, more than any other student, has made use of his geometry."

Some of the real problems of geometry encountered by this boy in the manufacture of pennants were printed in SCHOOL SCIENCE AND MATHEMATICS in October, 1910.

Miss Lida C. Martin, Decatur, Ill., had one boy bring in several problems encountered at a local bridge factory. One of these was printed in SCHOOL SCIENCE AND MATHEMATICS in October, 1910.

**Problems of General and Local Interest.**

It is evident that there are many real applied problems of algebra and geometry that are of such a nature as to appeal to the interests and comprehension of pupils of all localities. They are problems encountered in fields of activity that enter into the experiences of the average person everywhere. A number of problems printed in SCHOOL SCIENCE AND MATHEMATICS are of this kind. Such problems as these should in time be worked into our text-books, where they will be available for use in the most economical way in all schools. Just as in elementary school mathematics the successful text-books which are written for use in all parts of the country can contain only those problems that have to do with things relating to the experiences of all children, so a text-book in elementary algebra or geometry written for general use in all localities can contain only such real problems as touch the experiences and interests of all pupils to a greater or less extent. It is hoped that, in the future, writers of text-

books on algebra and geometry for secondary schools will introduce in a careful way more and more of those real applied problems that are of interest to all pupils and that have been tried out in schools. In fact, it can be only through this introduction of real applied problems into the text-books that these problems can ever become available for general use in all schools, and become the integral part that they should become of our courses in elementary algebra and geometry. It must be not only through the activities of individuals and organizations of teachers such as ours, but through the writers of text-books, cooperating with these, that this real problem movement should be carried forward in the future.

But the great majority of applied problems are of interest only to individuals or special groups of individuals. A problem of interest to pupils in one locality, or to pupils looking forward to some one vocation, may be foreign to the experiences of, or without interest to, all other pupils. Hence, the desirability of supplementing, in each school, the printed problems adapted to the use of pupils everywhere, which it is hoped will in time be incorporated into the text-books, by the problems of local interest that have to do with things in the immediate environment of the school. That problems of this type can be found in practically every community there can be little doubt. Illustrations of this are shown in the problems printed in SCHOOL SCIENCE AND MATHEMATICS, October, 1910, that were encountered by pupils in Toledo, O., and Decatur, Ill. Others were suggested above, in the reports of teachers in Portland, Ore., and elsewhere. This problem material of local interest must be collected by the individual teacher in each community, aided by the pupils themselves, acting through her inspiration.

**Prospect.**

There is much evidence of the growing popularity of this real problem movement throughout the country. The committee has received increasing encouragement in the work from many interested and enthusiastic teachers in all parts of the United States. At the meeting of the National Education Association in Boston, July, 1910, a paper was read by Mr. W. E. Breckenridge, Stuyvesant High School, New York City, on applied problems. This paper will be found printed in the Proceedings of the N. E. A. for 1910. Teachers will find in it a strong argument for the use of real applied problems, thus furnishing

an index to the interest in the real problem movement now being manifested in the Eastern States. That the movement will prove to lead in time to a permanent reform in the teaching of secondary mathematics we firmly believe. And it will be a matter for gratification if the work of this committee, superficial as it has been, in demonstrating the possibilities in the movement, and in helping to stimulate the interests of teachers in it, through problems collected and printed, through some of the sources of problem material that have been suggested, and through the efforts to get the adaptability of problems tested in the school room, may not prove a total waste.

JAMES F. MILLIS, *Chairman*,
Francis W. Parker School, Chicago, Ill.
JOS. V. COLLINS,
State Normal School, Stevens Point, Wis.
C. I. PALMER,
Armour Institute of Technology, Chicago, Ill.
E. FISKE ALLEN,
Teachers' College, New York, N. Y.
A. A. DODD,
Manual Training High School, Kansas City, Mo.

## FORMULAE FOR RATIONAL RIGHT TRIANGLES.

The following table is given in the February, 1910, number of *Indian Education*.

| | A | B | $\sqrt{A^2+B^2}$ | Authority |
|---|---|---|---|---|
| 1 | $2a(a+1)$ | $2a+1$ | $2a^2+2a+1$ | Pythagoras |
| 2 | $4a$ | $4a^2-1$ | $4a^2+1$ | Plato |
| 3 | $\sqrt{ab}$ | $(a-b)/2$ | $(a+b)/2$ | Euclid |
| 4 | $2ab/(b^2+1)$ | $a(b^2-1)\ (b^2+1)$ | $a$ | Diophantus |
| 5 | $2ab$ | $a^2-b^2$ | $a^2+b^2$ | Brahmagupta |
| 6 | $\sqrt{a}$ | $\frac{1}{2}(a/b-b)$ | $\frac{1}{2}(a/b+b)$ | " |
| 7 | $a$ | $2ab/(b^2-1)$ | $a(b^2+1)(b^2-1)$ | Sridhara |
| 8 | $a$ | $\frac{1}{2}(a^2/b-b)$ | $\frac{1}{2}(a^2/b+b)$ | Bhaskara |
| 9 | $2lmn$ | $l(m^2-n^2)$ | $l(m^2+n^2)$ | Gen'l Formula |

# PRELIMINARY REPORT OF THE "NATIONAL COMMITTEE ON GEOMETRY SYLLABUS" AND ITS PRACTICAL PEDAGOGICAL IMPLICATIONS.[1]

By William Betz,
*East High School, Rochester, N. Y.*

## HISTORICAL RETROSPECT.

### First Tendencies toward Standard.

It may not be out of place, by way of introduction, to trace the connection between the work of this committee and similar efforts in the past. This historical retrospect must necessarily be very brief.

The National Education Association, so far as I know, was the first body of teachers in this country that recognized the importance of national standards in education. Ever since its organization, in 1857, it has powerfully affected the educational activities of the country. Much of this influence was due to the efficient work of its committees. The first N. E. A. document that attracted world-wide attention was the now celebrated "Report of the Committee of Ten on Secondary School Studies" (published separately by the American Book Co., 1894). The Committee of Ten was appointed at the meeting of 1892. Under the chairmanship of President Eliot it organized so-called conferences on all high school subjects. The mathematical conference was in charge of a subcommittee of ten; Professor Simon Newcomb, of Johns Hopkins, being the chairman. Of other distinguished members I will name Professor Byerly, Professor Cajori, Professor Fine, and Professor Olds. It is significant that only two public high schools were represented on the committee. The final report was the result of a conference lasting three days, held at Cambridge, Massachusetts, December 1892. A number of conclusions reached by these gentlemen were very important and at once influenced mathematical teaching. The committee recommended an introductory course in concrete geometry, begun at the age of ten, and lasting at least three years. It emphasized especially the necessity of much more oral work, and called attention to the function of original problems in demonstrative geometry. It declared that

[1] The National Committee of Fifteen on Geometry Syllabus was organized under the joint auspices of the National Education Association and the American Federation of Teachers of the Mathematical and Natural Sciences. They have been at work for nearly two years and hope to present a final report in 1911. This statement of progress was made by Mr. Betz on behalf of the committee at the Boston meeting, 1910.—The Editors.

"geometry cannot be mastered by reading the demonstrations of a text-book." However, the report had nothing to say about a uniform system of propositions.

In 1899, the Committee on College Entrance Requirements—after four years of careful investigation—presented its famous report. In mathematics its recommendations were practically in agreement with those of the Committee of Ten, but gave more attention to the mathematical curriculum. Incorporated in the main report was a supplementary report, submitted by the Chicago section of the American Mathematical Society. The latter document was prepared by a committee of ten, only two being high school teachers. Professor J. W. A. Young was the chairman. Excellent pedagogic suggestions were offered, and the importance of concrete geometry and of a preliminary course in demonstrative geometry was again pointed out. The reports of 1899 are epoch-making also in that we are offered for the first time a clear recognition of the desirability of a six-year curriculum. (See Proceedings 1899, pages 659, 700, 701).

It will be seen that in all these reports there is no thought whatever of a national geometry syllabus. That idea was advanced for the first time, so far as I know, by Mr. George W. Evans of Boston, at the meeting of 1901. The "Proceedings" say that Professor Evans suggested "that a carefully selected collection of propositions would be of great value to teachers and students of geometry, as furnishing a common basis of reference and a syllabus that may be used in examinations for admission to college." He advocated the appointment of a committee to take the matter in hand. The motion was carried and a committee of eight high school teachers was appointed. As the subsequent volumes have nothing to say concerning this committee, we must assume that it died a premature death.

In 1903 Professor Tyler of Boston presented a brief preliminary report of the American Mathematical Society, on college entrance requirements. The passage referring to plane geometry contains *three* sentences.

**First Syllabi.**

In 1904 Mr. Evans, not discouraged by the failure of his first committee, found a more auspicious soil for his efforts in the newly organized Association of Mathematical Teachers in New England. In that year, at its Boston meeting, the Association voted: "That a committee be appointed by the chair to consider recommending the approval by the Association of a syllabus of

geometry now in existence, or to draw up a syllabus, and that this committee confer with organizations similar to this one and report at the next meeting." A committee of six was appointed, with Mr. Evans as chairman. Three of its members were high school men. The desired syllabus was finally prepared, after a series of sixteen meetings and much preliminary correspondence. An attempt was made to secure the coöperation of other Associations. The list of propositions in this syllabus is very complete. Logical sequence is intentionally ignored; but the topical plan is retained. Besides, there are a few suggestions to teachers.

Evidently the New England syllabus did not become generally known, a fact much to be regretted. Two years later, in December, 1906, a Syllabus Committee of four, appointed by the Central Association of Science and Mathematics Teachers, presented a preliminary report. This report gained wide circulation. It contained brief discussions of a number of mooted topics, such as terminology, indefinables, assumptions, pedagogy. It endorsed the careful study of a much smaller number of propositions. The list of theorems submitted was very condensed. I cannot help feeling that the general excellence of this report is marred by a number of unfortunate contradictions. In one sentence, for example, hypothetical constructions are endorsed, for it is recommended that "no demonstration be deemed invalid because of assuming the possibility of constructing the figure used." The very next sentence says: "In the first theorems involving superposition the actual construction should be followed instead of appealing to the imagination." One paragraph advocates the experimental verification of certain mensurational facts, and the very next paragraph tells us that "the treatment of mensuration in most texts is extremely unfortunate," the demands of rigor not being met. On the one hand the pupil is not to be confused with subtleties, and on the other he is expected "to verify by observation and experiment and to record in a notebook" such astounding "assumptions" as this, "A sect has one and only one midpoint." Let it be conceded, of course, that the harmonizing of the liberalism of a Perry and of the rigor of a Hilbert is the very difficulty confronting the geometry teachers.

In concluding this historical summary, we can safely say that at present no syllabus thus far published has secured anything approximating national significance. This applies also to the Harvard syllabus. It seems to me that the reasons for this result were the following:

1. The membership of the committees was too small.
2. The reports were too one-sided.
3. High schools and colleges were not represented in equal numbers.

**The National Geometry Syllabus Committee.**

Two years ago, at the Cleveland meeting of the N. E. A., it was my privilege to read a paper on the teaching of geometry. Realizing the insufficiency of existing syllabi, I recommended the appointment of a national geometry syllabus committee, and outlined a plan of procedure. Professor H. E. Slaught was authorized by the mathematics section to organize such a committee. "Lack of permanence of organization, and therefore of right to appropriate money, on the part of the sections temporarily stopped the work, although Dr. Slaught continued to canvass the country for representative men to form the committee. At the Baltimore meeting of the American Federation of Teachers of the Mathematical and the Natural Sciences, in December, 1908, Mr. E. R. Smith, as the representative of the Middle States and Maryland Association, presented the matter to the Federation, and urged the continuance of the work apparently dropped by the N. E. A. The Federation at once adopted the scheme, accepted Dr. Slaught as chairman, and to avoid losing the work already done by him, asked him to nominate to the Executive Committee the teachers he thought should be on the Committee. Soon afterwards the N. E. A. again took up the matter, and as a result a joint committee of fifteen was appointed. This committee was then divided by the chairman into three sub-committees." [2]

**Preliminary Report of Geometry Syllabus Committee.**

Having brought the history of this movement up to the present year I shall submit a very brief outline of the work done by the committee thus far. I am authorized to present, first of all, the following report of the chairman, Professor H. E. Slaught.

*Chicago, June 23, 1910.*

To the Mathematics Section of the Secondary Division of the National Education Association:

Your Committee on a Syllabus in Geometry presents the following report on the organization and progress of the work entrusted to it:

Immediately after the joint authorization of this committee

[2] See the Mathematics Teacher, June, 1910.

(explained above) an extended correspondence was begun looking toward the selection of the members so as to fairly represent the various sections of the country, and the chief educational interests with respect to the teaching of geometry. This canvass resulted in the selection of the following fifteen members of the committee, seven from colleges or universities, and eight representing secondary schools.

H. E. Slaught, Chairman, The University of Chicago; C. L. Bouton, Harvard University; F. Cajori, The University of Colorado; H. E. Hawkes, Yale University; E. R. Hedrick, The University of Missouri; H. L. Rietz, The University of Illinois; D. E. Smith, Columbia University; William Betz, East High School, Rochester, N. Y.; E. L. Brown, North High School, Denver, Colo.; William Fuller, Mechanic Arts High School, Boston, Mass.; W. W. Hart, Shortridge High School, Indianapolis, Ind.; F. E. Newton, Phillips Academy, Andover, Mass.; E. R. Smith, Brooklyn Polytechnic Institute, Brooklyn, N. Y.; Mabel Sykes, South Chicago High School, Chicago, Ill.; R. L. Short, Technical High School, Cleveland, O.

Early last summer a preliminary organization of the committee was effected, and each member contributed in writing a statement of the situation with respect to geometry in the schools as it appeared to him, together with whatever suggestions he desired to make, either as to methods of procedure, reforms to be proposed, purposes in view, results desired, and so forth. These were manifolded in July of last year and complete copies placed in the hands of all the members, together with a résumé of what seemed to be the salient features gathered from all these preliminary suggestions. In this way each member was fully informed of the point of view of each of the others, and all were thus prepared to undertake the work with a full understanding of the situation so far as the members of the committee had analyzed it up to that time.

It was then proposed that the committee resolve itself into three subcommittees of five members each to address themselves respectively to the following phases of the work:

(1) LOGICAL CONSIDERATIONS, including axioms, definitions, symbols, new terms, forms of proof, treatment of limits and incommensurables, purposes whether formal or practical, place in a curriculum, etc. etc.

(2) LISTS OF BASAL THEOREMS, including types of courses as

given in various countries, types of courses for different classes of students, for non-college preparation, minimum list of theorems for various standard courses, grouping or classifications of theorems, etc., etc.

(3) EXERCISES AND APPLICATIONS, including the grading and distribution of exercises, relative importance of algebraic and geometric work, special classes of exercises such as loci problems, correlation with other subjects, such as trigonometry, concrete applications related to drawing, decoration, architecture, ornamental design, mensuration, surveying, machinery, etc., etc.

The membership of these subcommittees is as follows: On logical considerations, D. E. Smith, chairman, William Betz, C. L. Bouton, E. R. Smith, William Fuller. On Lists of Theorems, E. R. Hedrick, chairman, W. W. Hart, E. L. Brown, F. Cajori, H. E. Hawkes. On Exercises and Applications, H. L. Rietz, chairman, R. L. Short, F. E. Newton, Mabel Sykes, H. E. Slaught.

These subcommittees have been organized and have worked during the past year, and extensive investigations have already been made in preliminary form. It is proposed to carry on the work of the subcommittees to as great a degree of completion as possible and then to bring the report of their work before the committee as a whole for full consideration, discussion, and action. Not less than a year longer will be required to bring the work to completion.

In the meantime, the committee finds itself hampered by lack of funds for the prosecution of the work. So far the expenses have been met, for the most part, by the personal contribution of the members. But soon the cost of manifolding preliminary reports will increase, and later the printing of the final report will demand consideration. It would be well if the committee might know at this time approximately to what extent the National Education Association will back it up in the cost of prosecuting the work.

Respectfully submitted,

H. E. SLAUGHT, Chairman.

A preliminary report of subcommittee one was published in the June 1910 number of "The Mathematics Teacher." A persistent effort was made to embody a sanely conservative point of view, and yet to open the door to progress.

Subcommittee two, through its chairman, Professor E. R. Hedrick, has forwarded to me a very interesting partial statement

of its work. As the document is very voluminous, it cannot be given *in toto*. It embodies a bibliography on the teaching of geometry, and a history of attempted revisions of geometry. Being prepared by the authoritative pen of Professor Cajori, this part of the report will be of extreme value to American teachers. I cannot refrain from including the last two pages, which give the history of geometry teaching in the United States.[3]

"During the seventeenth century, arithmetic and geometry received some attention in the last year of the college course at Harvard College. In 1726 Alsted's Geometry is mentioned as a text-book studied by Harvard seniors, but as soon as geometry came to receive serious attention in American colleges, Euclid became the text used. The first mention of Euclid at Yale that we have seen is in 1733, at Harvard in 1737. In the latter part of the eighteenth century, geometry was taught to lower classmen. According to a member of a Harvard class of 1798, 'the sophomore year gave us Euclid to measure our strength.' In 1801, Professor Webber said: 'A tutor teaches in Harvard College Playfair's "Elements of Geometry."'

"In 1813 the 'Analytical Society' was formed at Cambridge, in England, which aimed to encourage in England the vigorous study of French higher mathematics. The influence of this movement reached the United States. In about ten years American teachers began to adopt French texts. Collateral events at West Point had the same tendency. There elementary mathematics was taught from 1808 to 1810 by F. R. Hassler, who was a graduate of the University of Berne in Switzerland.

"In 1817 Crozet, of the Polytechnic School in Paris, introduced descriptive geometry into West Point.

"In 1819, John Farrar of Harvard brought out a translation of Legendre's Geometry, which, with translations made by him of other French and Swiss texts on mathematics, was at once widely adopted in the leading American colleges. American teachers were willing to turn to the French, not only for works on the calculus and celestial mechanics, but also for books on elementary mathematics. *So it came about that Euclid was replaced by Legendre.* In 1828 Charles Davies, Professor at West Point, brought out an edition of Brewster's translation of Legendre's Geometry. Davies did not enunciate propositions with

[3]The contribution of Professor Cajori will appear in full in the October issue of the American Mathematical Monthly.

reference to and by the aid of the particular diagram used for the demonstration and to that extent returned to the method of Euclid. Davies' edition became widely popular under the name of 'Davies-Legendre,' and was much used in the United States as late as the seventies.

"One of the earliest American geometries worthy of note was that of Benjamin Peirce. The Harvard Catalogue of 1838 announces that Freshmen take Peirce's Geometry. Peirce favored the use of infinitesimals and also the use of the term *direction*, a concept probably first used in this country by a Harvard teacher named Hayward in his geometry of 1829. Peirce's text did not become widely popular, for like his other elementary books, it was too condensed for immature students. *In 1843 or 1844 Harvard first made geometry a requirement for admission to college.*

"In 1851 Professor Elias Loomis of Yale used a geometry which was revised in 1871. Loomis came under French influence as a student in Paris. In the second edition of his text he says: 'The present volume follows substantially the order of Blanchet's Legendre, while the form of the demonstrations is modelled after the more logical method of Euclid.' It has been said of American writers, that while they have given up Euclid, they have modified Legendre's Geometry so as to make it resemble Euclid as much as possible. This applies to Loomis with greater force, perhaps, than to any other author.

"In 1871 Professor Olney, of the University of Michigan, published a geometry under two main heads:

"I. *Special or Elementary Geometry*, comprising (1) Empirical Geometry, (2) Demonstrative Geometry, (3) Original Exercises in the Application of Algebra to Geometry, (4) Trigonometry.

"II. *General Geometry* (Plane Loci).

"Olney was a self-educated man. He was a great teacher and had original ideas about teaching. It is said that he was prevented by his publishers from departing very far from the traditional classification. His ideas were novel and forecasted in many ways the present tendencies in mathematical teaching. His geometry shows that he attempted to correlate the various mathematical topics, and to introduce applications to everyday affairs. Olney's books were used quite extensively in the Middle West, but acquired no foothold in the East.

"Just before the death of William M. Chauvenet, in 1870, appeared his geometry, the only elementary book he wrote. Closely following French models, exhibiting a wonderful ease and grace of style, Chauvenet produced a remarkable book, which was used in many of the best schools. He included as a part of the work an introduction to modern geometry. Perhaps no work on geometry ever published in the United States has been so highly respected as this.

"In 1878 appeared the geometry of G. A. Wentworth, which is still in use. We omit all discussion of it, as also of later books which have been published in this country.

"The researches on non-Euclidian Geometry, begun in the eighteenth century in Italy and Germany, and brought to fruition in the early part of the nineteenth century, did not produce an appreciable effect on the teaching of elementary geometry until the last quarter of the nineteenth century. It was in 1867 and 1868 that Baltzer, Battaglini, Grunett and Hoüel brought Bolyai and Lobatchevsky to the attention of the mathematical public at large.

"The new ideas have not affected the teaching of elementary geometry except in some of the definitions and postulates. They have assisted in the rejection of the definitions, 'parallel lines are lines everywhere equally distant' and 'parallel lines are straight lines which have the same direction.' They have shown the futility of 'proving' the parallel-postulate and have led to the use of the word 'axiom,' not as 'self-evident truth,' but as a synonym for 'postulate.'

"In conclusion, we note that with the beginning of the twentieth century England began once more to influence the teaching of geometry in the United States, through the so-called 'Perry movement,' and that Germany, which at no time during the nineteenth century affected geometrical teaching in America, makes itself felt at the present time through the pupils of Klein and Hilbert and through the international movement toward reform in the teaching of mathematics, headed by Klein."

### Practical Pedagogical Implications.

Ever since we gave up Euclid as a standard, we have had a great many widely diverging geometric texts. The field of geometric relations is, of course, infinite, and the entry into that field can be made in more ways than one. This subjective tendency is not in itself alarming. The teacher is embarrassed by it only because there has not been a corresponding liberality

in examination requirements. Uniform examinations, such as those given by the Regents of New York State, or by the College Entrance Examination Board, imply some agreement as to the essentials of a subject. This uniformity is only vaguely defined in the college catalogues, by the statement, "as much as is contained in the better text-books." The text-books on the other hand have based their conception of the essentials on the College Entrance Examinations. So we are going around in a vicious circle. If your committee succeeds in turning out a satisfactory syllabus, the practical results ought to be a complete remedy of many of these difficulties, especially the following.

**I. Examinations.**

The syllabus should furnish a national standard for geometry examinations. It is prepared by representatives of leading colleges and high schools. Moreover, the present committee may be said to embody the cumulative efforts of eighteen years of continuous development, since Prof. Cajori belonged to the original Committee of Ten and Prof. Bouton helped to frame the New England Syllabus. Hence, I earnestly bespeak the support of all the examining bodies concerned.

**II. Uniformity vs. Freedom.**

I know that most of us have a justifiable horror of uniformity. But let us remember that a little more uniformity is better than the prevailing chaos of texts and examinations. The work of this committee will in no way even remotely affect the freedom of the teacher. I wish to make this point very emphatic. The committee does not expect to lay down a logical sequence of propositions, thus leaving it to authors and teachers to make their own approach. It *does* wish to give a list of basal theorems, together with suggestions on maximum and minimum courses. Thus the teacher—if this syllabus should become generally accepted—will know exactly what ground is to be covered, without being hampered as to method.

**III. Time.**

The committee may recommend that one and one-half years be devoted to plane geometry, in which time also a few facts from solid geometry and trigonometry could be incorporated.

Schools all over the country are getting ready for a six-year curriculum. Many of our difficulties are due to lack of time. It is well known that the number of geometry students is less than

half that of the algebra students, and yet the percentage of failures is from forty to fifty per cent, and it is usually higher than in algebra. This shows that we need more time. The extension of time recommended by the committee, together with the greater definiteness provided by the syllabus, will at once react favorably on the results of our teaching.

**IV. Applications.**

The question of real applications is very central at present. The committee hopes to be of great service to the teachers by summarizing all that has been done in that direction up to date.

**V. Disputed Points.**

The report embodies a brief discussion of such matters as indefinables, axioms, new symbols. In regard to incommensurables and limits, it will undoubtedly endorse the present tendency of making these topics entirely optional.

**VI. Pedagogy.**

The report will refrain from orthodox prescriptions of method. It will contain valuable bibliographies and references and will help to harmonize antagonistic tendencies.

## THE TEACHING OF PHYSICS.[1]

By Thomas M. Balliet, Ph.D.,

*Dean of the School of Pedagogy, New York University.*

Physics rightly taught ought to be one of the most popular studies in secondary schools. Instead statistics show that under the elective system which prevails very generally in these schools, the classes are small, and in many schools the per cent of pupils that elect the subject is decreasing. There is surely something wrong which needs correction. Progressive teachers of physics all recognize it and are trying to find the corrective. They are the only persons competent to work out the problem.

The defect in the teaching of physics is not due to insufficient knowledge of physics on the part of our teachers. Teachers of physics in our better class of high schools are, as compared with the past, exceptionally well trained. The remedy therefore lies not in a more thorough training in physics, as some professors of physics in our colleges maintain.

The defect is not due to the lack of laboratory facilities. Our high school laboratories are, for the most part, well equipped.

[1]Report of an informal talk before the New York Physics Club.

If I may be dogmatic for the sake of brevity, I would state the case somewhat as follows:

1. The course is too crowded, too many topics are treated. Many of the topics do not appeal to high school pupils and are better adapted for college classes. In short, the content of the course is not selected sufficiently with reference to the pupil's capacity and interest; it is selected to "fit for college." For this the colleges are mainly responsible.

2. The study of physics as a means of education has two important functions; it must interpret to the pupil the physical phenomena in his environment, and it must develop in him scientific methods of observation and thinking.

3. To interpret to the pupil the physical world about him, physics must be taught as an applied science and not as a so-called "pure" science. I think most of us recognize that here is the weak spot in the teaching. The laboratory work in physics in our secondary schools has been disappointing. It fails to interest pupils as was expected. The reason is that we do not go beyond the generalization. Pupils observe the experiment, discuss it, formulate the generalization and copy it into a notebook. That is the end of it, while it should be merely the beginning of the real instruction. The generalization should be taken out of doors and made to explain as many facts and phenomena in nature as possible. That would appeal to pupils. Laboratory physics is a means; the end is the interpretation of the physics out of doors. There is more educational value in teaching one generalization in physics and making fifty well selected applications of it than in teaching fifty generalizations and making no applications. There is no reason, for example, why the whole of elementary meteorology should not be taught in physics and as physics. Many topics in physical astronomy are intensely interesting to high school pupils. Much of physiography and dynamic geology should be taught in connection with physics. Applications should be made to agriculture and to manufacturing. It is this interpretation of life which makes science interesting to immature pupils and not pure science. That has its place in the college and the university.

All the sciences should at first be taught in their application for the purpose of capturing the interest of pupils, later as pure sciences in the college, and then again as applied sciences in the technical schools for practical reasons.

This applies to a large extent also to mathematics. Economics

has ceased to be the dogmatic, formal study it was years ago, and is surely no less scientific because it is made to explain the facts of our economic life. Even psychology is becoming an applied science and is made to explain the facts of our mental life, individual and social.

4. But we must go farther than merely to apply the generalizations of the laboratory based on arbitrarily prescribed experiments. We must not prescribe experiments as many of our courses have done and some are doing still. The end of physics is not the experiment but the solution of a problem. The pupil must not merely take his generalizations out of doors; he must first of all find his problems out of doors. The physical phenomena in his environment must furnish the problems to be attacked in the laboratory. The problem determines the experiment and the experiment the apparatus. I have known cases where the teacher followed the reverse order. Experiments must be discussed before they are made as well as after they are made. This is the true scientific method. To prescribe an experiment and then tell pupils to make it and observe what they can see, is not scientific. It is too aimless. No scientific man works that way. He always has a definite problem to solve, this determines his experiment, and that determines the apparatus. He frequently has to make the apparatus.

To illustrate what I am attempting to say: Instead of beginning with an experiment in taking up specific gravity, after asking a few questions about objects which float on water and objects which sink, propose the question how it is possible to make a steel merchant vessel and an armored battle ship float.

Or to take a more complex problem which involves several physical principles: After questioning the class about the relative weight of cold air and warm air, ask them why the cold air on the Alps does not roll down into Italy and make August almost as cold as January; or why the still colder air on the plateau of the Himalayas does not roll down and freeze out the people of India even in midsummer. I need not multiply illustrations. Science in secondary schools must not only be applied to life, it must find its problems in life; and to prescribe a course of study in terms of experiments, as we have done in physics, implies a wrong conception, it seems to me, both of the aim and of the method of the instruction in this subject.

## A PRACTICAL LESSON IN PHYSICS.[1]

By E. K. McAlister,
*West High School, Rochester, N. Y.*

To determine the horse power of a gas or gasoline engine by means of the prony brake.

The engine is put in position and connection made with the gas supply. Two spring balances, with a range of at least 25 pounds, are fastened to a support directly above the driving pulley. A leather belt of the proper length and width is placed around the pulley, each end of which is attached to the hooks of the balances, causing a pressure of about 10 pounds to be indicated on each, as shown in Figure 1.

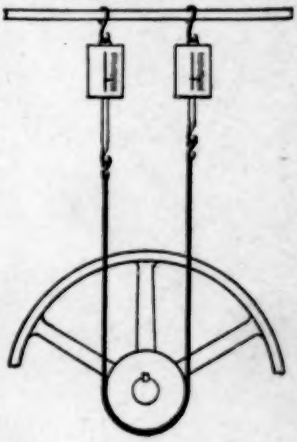


Fig. 1.

The bearings having been well oiled, the gas is turned on and the engine started. It is now noted that the balances do not indicate equal readings, that while the reading of one increases the other decreases. As soon as the right mixture of air and gas has been secured and the engine working at its best advantage the reading of the balances is taken, one reading 16 and the other 4.5 pounds. By means of a speed indicator and stop watch the number of revolutions per minute of the driving shaft is taken; this is found to be 910. The diameter of the driving pulley is found to be 0.25 of a foot.

From these data the horse power of the engine is computed by the formula

$$\frac{P \times D \times 3.1416 \times RPM}{33000}$$

where P represents the difference in reading of the two balances, $B_1$ and $B_2$, Figure 2, D the diameter of the pulley in feet, RPM the number of revolutions per minute and 33,000 the number of foot pounds of work done in a minute by one horse power.

[1]This experiment was carried out and written up by Mr. McAlister, a pupil in physics of the above school.

Substituting in this expression, the horse power of the engine is found to be .249.

This is an experiment which the boys of this school like to perform. The test may be carried out with different loads, thus changing the r. p. m.

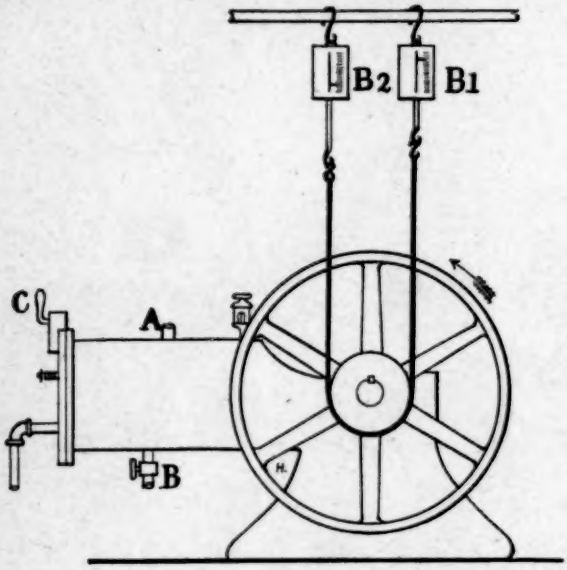



FIG. 2.

## MEASURING THE INDEX OF REFRACTION OF A GLASS PRISM.

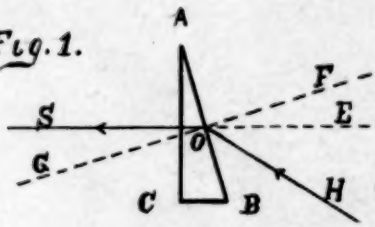
BY J. P. NAYLOR, M.S.,
*Professor of Physics, DePauw University.*

A simple adaptation of Descartes' method for measuring the mean index of refraction of a glass prism has been used so successfully in the elementary classes at Minshall Laboratory that it is thought that it might be worth while to explain the method used to the readers of SCHOOL SCIENCE AND MATHEMATICS. This arrangement of the experiment has the advantage that it does not require an expensive spectrometer but only such simple apparatus as is found in every laboratory, and the principles involved are applied so directly that the student does not lose sight of them in the manipulation of a complex piece of apparatus.

In the method of Descartes it is required that the light fall perpendicular on one side of the prism. The simple formula expressing the relation between the index of refraction, the angle of the prism, and the deviation of the ray by the prism may be found as follows:

Let ABC, Fig. 1, be a prism and HOS the trace of a ray of light through the prism. Draw FG perpendicular to AB. Then FOE is evidently equal to A, the refracting angle of the prism, and also equal to SOG, the angle of refraction, R, of the ray at the surface AB. The angle of incidence, I, is FOH and the angle of deviation, D=EOH. Therefore I=A+D. Substituting these values of I and D in Snell's formula $u=\sin I/\sin R$ we get $u=\sin (A+D)/\sin A$ where A and D are the quantities to be measured to determine the index of refraction of the glass.

*Fig. 1.*




In order to measure A and D a sort of optical bench is arranged, consisting of a straight board about 5 feet long, 4 inches wide, 1¼ inches thick with a straight meter stick fastened along the edge of one side. This meter serves as a guide to a block that can be moved along the surface of the board. The block may be about 8x4x1¼ inches and has an index line drawn across one edge by which to read distances on the guiding meter. At right angle to the middle of one side of the block is fixed an upright piece about 3x¾ inches and 12 inches high with a ¾ inch hole bored through it 2 inches from the upper end. Just below the hole, and at right angle to the upright, is fastened a little block, ⅜ of an inch thick, which forms a ledge or shelf on which to place the prism.

At one end of the board a meter is fixed in a vertical position, and beyond the opposite end a small telescope is leveled and adjusted so the scale can be read through the hole in the upright piece.

In practice the prism is placed back downward on the ledge and covering the hole in the upright and the sliding block is moved to a position near one end of the guiding meter. Readings are taken of the position of the index line of the block on the scale of the guiding meter and of the upright scale seen by means

of the telescope through the prism. The block carrying the prism is then moved toward the other end of the board and a second pair of readings is taken. The difference between the vertical scale readings divided by the distance over which the prism has been moved will give the natural tangent of the angle of deviation, D. The corresponding sine can be obtained, of course, from trigonometric tables.

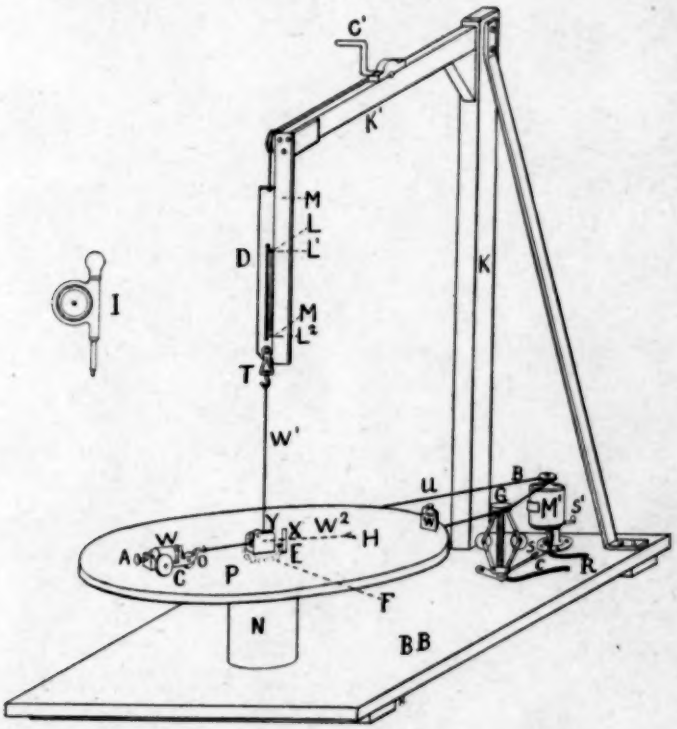
To measure the angle of the prism, the telescope is moved to the opposite end of the board near the vertical scale and adjusted so the scale can be seen in a small piece of thin mirror placed against the surface of the prism. The scale is read and then the prism is removed and another reading of the scale is made with the mirror placed against the surface of the upright. One half the difference between the scale readings divided by the distance from the surface of the prism from the vertical scale will give the natural tangent of the angle of the prism. There may be a slight error due to uncertainty of the point on the prism from which to measure the scale distance, and due to the thickness of the mirror. This error will be inappreciable, however, if the scale distance be made as long as possible. The uncertainty noted above may be entirely avoided by sliding the block and using a difference method as in measuring the angle of deviation. But in this case the telescope will have to be refocused for the two scale distances and to avoid any possibility of its being moved between readings the telescope should have a rack and pinion focusing device. The values of A and D thus obtained should give, in the formula, a very close approximation to the index of the glass of the prism.

The prism used in this work may be a thin one, of 10 or 12 degrees angle, such as can be supplied, for a few cents, by any jeweler who sells spectacles. The back of the prism should be made parallel to the axis of the prism. This can be done by grinding with powdered emery or carborundum with water on a piece of plate glass. The parallelism of the back and axis will be nearly enough attained when the edges of the back are parallel as tested by means of a vernier caliper or micrometer screw. When grinding the prism back it should be held by the ends so as to avoid marring the polished surfaces by any emery that might get on the fingers. For the same reason the emery that will get on the surfaces, while grinding, should be washed off by dashing water over it, rather than by rubbing the surface.

## CENTRIFUGAL FORCE.

The apparatus for this experiment was made and the experiment worked out by two boys in the second year class of the Arlington High School, Arlington, Massachusetts.

The object of the experiment was to verify the formula for centrifugal force which is: $F = \frac{M(VV).}{gR}$ When M = mass of rotating body; V = velocity; $g$ = acceleration due to gravity; R = radius of circumference through which mass is rotating.




Apparatus consists mainly of wooden disk P about 2 ft. 6 in. in diameter, mounted on the base BB and rotated on ball bearings F; an inverted L shaped arm K, 3 ft. long, placed so that the end of its arm comes directly over the disk. A three wheel car C, on the disk receives the weight W. A wire W′ passes from the car through the pulley Y to the swivel T, which is connected to the dynamometer D, that being suspended by a rawhide cord K′. The other end of K′ is made fast to crank C. The disk is

rotated by means of the electric motor M′, which communicates motion to the disk by means of belt B. A governor *g* is also run by B, which makes a "make or break contact" of electricity at *c*. The Z-shaped part XE near the center of the disk is used as clutch for the speed indicator I, and for convenience can be swung aside, with E as an axis, when not in use.

The following is some of the data obtained with the use of this apparatus:

| READING | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| MASS In kilograms | .335 | 1.135 | 1.135 | 1.135 | .567 |
| VELOCITY c.m. per sec. | 210 | 282.75 | 282.75 | 141.35 | 282.75 |
| RADIUS In centimeters | 15 | 15 | 30 | 15 | 15 |
| CENTRIFUGAL FORCE by FORMULA In kilograms | 1.005 | 6.16 | 3.08 | 1.54 | 3.08 |
| CENTRIFUGAL FORCE by APPARATUS In kilograms | .997 | 6.27 | 2.85 | 1.69 | 3. |
| DIFFERENCE Average .058 | .008 | .11 | .23 | .15 | .08 |

In operating this apparatus, the first thing to be done is to unhook W′ from swivel T and hook it at H, at the same time swinging X on axis E so that X will be above center of the disk P. A weight is placed in the guide U heavy enough to balance weight of car C. The approximate speed is decided upon and the governor G is set accordingly at S. Wire R is connected to electric light circuit, and controller S′ is closed. When sufficient speed is acquired, the speed indicator I is placed on X. The speed having been taken for one minute, the motor is again shut off. Having once set the governor at S, the speed will always remain constant, regardless of any weight the disk may be subject to. X may again be placed in its former position. Also W″ is replaced in position W′ again. The desired weight is placed in car C. This car is so constructed that the center of gravity of the car plus the weight therein is in the two larger wheels; this is made possible by the adjusting screw A

and the auxiliary wheel O. Sufficient weight is placed in U to balance the weight of the car and its load on the opposite side, thus eliminating all possibility of vibration. The motor is again started. The two circumferences L′ L″ are shown to represent the paths that the car may be made to revolve in. Indicator M, which is also supported by the upright K, is marked L′ and L″ and represents 15 cm. and 30 cm. respectively, when they coincide with J of the dynamometer D. In order that this may be so, as the centrifugal force increases, the dynamometer must be elevated, for which the crank C is provided. The centrifugal force is registered on the dynamometer when the radius mark (L′, for instance) coincides with J.

Therefore this experiment shows that the formula for centrifugal force, $F=\frac{M(VV)}{GR}$, may be verified as follows:

The centrifugal force varies *directly* as the *mass*, when the *radius* and *velocity* are constant. Shown by readings 2 and 5:

2 M=1.135 kg. V=282.75 cm. R=15 cm. F=6.27 kg.
5 M= .567 kg. V=282.75 cm. R=15 cm. F=3 kg.

The centrifugal force varies as the *square* of the *velocity*, when the *mass* and *radius* are constant. Shown by readings 2 and 4:

2 M=1.135 kg. V=282.75 cm. R=15 cm. F=6.27 kg.
4 M=1.135 kg. V=141.35 cm. R=15 cm. F=1.69 kg.

The centrifugal force varies *inversely* as the radius, when the *mass* and *velocity* are constant. Shown by readings 2 and 3:

2 M=1.135 kg. V=282.75 cm. R=15 cm. F=6.27 kg.
3 M=1.135 kg. V=282.75 cm. R=30 cm. F=2.85 kg.

## GENERAL SCIENCE.

By Percy E. Rowell,
*Gardena Agricultural High School.*

Science teachers of the high schools have been endeavoring for some time to plan a graded course in science. They have claimed quite naturally that the pupil should have the easier science first, to be followed by the more difficult sciences, just as the easier branches of mathematics come first. The earlier result of their attempts was to have physical geography the first year, botany or zoölogy the second year, chemistry the third, and physics the last year of high school. It was then apparent that

physical geography required a little of all the other high school sciences, as well as bringing into the course other sciences not usually taught in high schools.

The divisions into which science has fallen are natural and therefore helpful to the advanced student. The reasons which underlie the sequence of their occurrence in a high school curriculum, however, often are not so pedagogical as imitative. Physical geography certainly requires as much scientific imagination—the highest result of education—as does physics. Then, also, fully one half of each of the so-called physical geographies is devoted to astronomy, meteorology, physics, chemistry, botany and commercial geography, all of which are good, but should not be considered strictly physical geography.

After physical geography had been tried, general science was proposed as an introduction to all of the sciences, including physical geography. The question which arose at once was—What is general science? For two years, at least, science teachers have been trying to answer this question as well as giving courses no two of which are at all alike. No solution which satisfies the majority has been reached, but all are agreed on one point. General science must not be specialized in any particular science. The sub-questions are: Should the elements of science be taught? In what order should the different sciences come in the course? Should there be experiments in all of the sciences? Could such a course be given in one year? Should science or scientific method be taught? What is meant by an introduction to science? What is the true object of such a course? What ought to be the plan of such a course?

Science has earned for itself, or has had thrust upon it, in the high school, a very bad reputation, at least in the minds of the pupils. The chief aim of a course in general science should be to remove this impression, right or wrong, and to arouse the scientific curiosity of the pupil, stimulating his ambition to continue deeper and deeper into the study of science. If this object is not attained, the course has fallen short of its mark. It must be remembered that the teacher is dealing with the immature minds of the grammar school graduate, not the minds of the more developed high school graduate. Classifications, pigeonholing corresponding acquisitions of specialized information according to psychological pedagogy, do not appeal to such a pupil as they may if he continues long in a highly specialized inhuman science. The pupil wants to know about what affects

himself. Tell him why he is hungry, why warm or cold, why he breathes; tell him what he sees, hears, feels, and make him want to appreciate more fully his own latent possibilities. In short, awaken him. Do not deaden him.

The youth of to-day has so much to learn about his own body, about his close surroundings, his fellows, in fact, about his highly organized life, that it is a pity to overlook these obvious calls for learning in order to develop properly the pedagogical sequence of scientific method. The final results are what show the success of a line of action. What can the orthodox scientists show in regard to the interest in, and eagerness for, high school science, as shown by the pupils? Yet science is the most interesting subject imaginable, has the greatest amount of possibilities of direct learning, applications and immediate results, and, in truth, is the only subject which can be vibrant with life, for it is—Nature. Why, then, is the study of science so detested in the high school? It is because the subject is divided into sections, many of which do not, and never will, touch the lives of the pupils.

The course which constantly has in view the teachings concerning the self, at first the smaller self, and later the larger self, will succeed in its object—it will make the pupils want to KNOW. It makes no difference how this object is accomplished. One successful teacher will do it one way, another through a different method. The final results are the test. If after a year's course the pupils really wish to continue in science, then, and only then, do we know that the course in general science has been a success.

If we attempt to teach the elements of every science we shall fail on account of the impossibility of such a course. The order of the subject-matter should be such that it will fall naturally into ever-widening circles, leading farther and farther from the central self. If the course can be strengthened by experiments they should be performed, partly by the teacher and partly by the pupils. The experiments should be simple, with very simple apparatus. The scientific method, which should be encouraged, is a desire for more exact knowledge. What else could be required which would accomplish so much toward true education, scientific or non-scientific? General science has ahead of it a glorious success, full of wonderful possibilities. Scientific classifications and mathematics have characterized the other sciences. Let general science be general and free from mathematics, teaching about the "Larger Selfishness."

# THE TEACHING OF THE SHAPE, ROTATION AND REVOLUTION OF THE EARTH IN THEIR EFFECTS UPON CLIMATE AND LIFE.

By H. M. Clem,
*Crane Technical High School, Chicago.*

(*Continued from October number.*)

Rotation and the East-west Zones of Light and Heat.

Not to stop here to discuss the facts about rotation, although the teacher can do so now, let us look at the consequences of rotation. As the earth turns eastward the vertical ray is not allowed to dwell more than a moment at any particular spot. It touches all points in an east-west line in succession about the earth in twenty-four hours. The tangent ray east of the vertical marks evening and the one west marks morning, and every point in an east and west line has morning and evening in succession. The tangent rays north and south mark the polar regions. At any one instant the light and heat are distributed over the earth like a cap as assumed in the discussion above when the earth was imagined as stationary, but as the earth is turning this concentric zone arrangement, which fits over the earth like a hood, slides westward over the face of the earth and it completes the circuit in twenty-four hours. This motion gives us belts of heat running about the earth in an east-west direction, such as we have at present upon our earth. To put the idea more concretely, the pupil may imagine that the rays of the sun are tipped with paint brushes that trail westward over the surface of the earth as it rotates eastward. The strong vertical ray would paint a line corresponding to the equator, the rays falling $23\frac{1}{2}°$ north and south respectively would trace the tropics of Cancer and Capricorn, and the tangent ray would play like a dim searchlight on the poles. All the rays in a line north or south of the vertical would paint a solid band of light (and heat), strong at the equator, growing dim at the poles. The teacher can present this even more concretely by trailing chalk over the surface of a rotating black globe, using colors if he likes, say red, yellow and blue, shading from the red to the blue from the equator poleward.

Places under the vertical ray now cannot grow so hot as assumed above, because a period of twelve hours (night) inter-

venes and points 90° east and west from the noon point are not so cold as imagined on a stationary earth because the vertical or more nearly vertical ray passes by that way once in twenty-four hours. The side of the earth away from the sun is warmer than in the assumed stationary conditions, just as the day is cooler because the sun shines on it for a longer or shorter period sometime during the twenty-four hours. Thus the belts of heat now run east and west and the general temperature is more equal over the earth than when the earth was imagined to stand motionless. The equalizing effect is most marked at the equator, and it diminishes poleward, for the slant of the rays is not so much varied by rotation in the latter as in the former zone.

### Rotation and the Succession of Day and Night, with Its Consequences.

A succession of day and night is seen to grow out of rotation. Any point now has an alternating period of dark and of light, a period of alternate loss and gain of heat. Thus a periodicity is established and extremes and monotony are both relieved, and the entire east-west circumference of the earth made inhabitable. The imaginative teacher can arouse much interest in the pupils by encouraging them to think of cases wherein there is a response to daily rhythm. For example, the dawn, increasing height of the sun until noon, and its subsequent sinking westward, with the accompanying changes in degree of heat, humidity and cloudiness, the approach of evening with its sunset splendors, its falling dews and rising stars, and loss of heat until morning breaks again. There is a recognition of this rhythm by the flowers. Some, as the morning-glory, opening with the coming sun and closing in the evening; others opening at night, like the four-o'clocks and the night-blooming cereus. The birds also adjust themselves to the period, some rising in the morning, others prowling at night. In the tropics, the insects appear in such order in the evening that the hour may be known by the kind of sting or bite received by the victim (Humboldt). The grazing cattle, antelope, etc., use the daylight, and with the sinking of the sun they must be on the fearful outlook for such prowlers as the lion, panther, jackall and hyena. Many examples of man's activity show how closely he is adjusted to the rhythmic effects of rotation. His sleeping and eating, his labors and amusements, his hopes and his fears go with the sun. Even

the policeman and burglar are social institutions springing out of the consequences of rotation.

ROTATIONAL EFFECTS ON THE DISTRIBUTION OF VARIOUS ELEMENTS OF CLIMATE AND LIFE IN EAST-WEST BELTS.

The east-west belting of temperature, discussed above, is the most important of all the climatic factors. The teacher should be able to trace the entire series of effects growing out of this cause even though he presents only a portion of them to his pupils. Any geography will show temperature belts of a general kind, such as "tropical," or "torrid," "intermediate," or "temperate," and "polar" or "frigid."

If a chart of the circulation of the world's atmosphere is consulted it will reveal a remarkably definite east-west belting of the winds, following broadly the direction of the temperature belts. There is along the equator or near it the belt of equatorial calms, where, according to sailors' stories, the ships stand as on a painted sea. Then the ever-steady, well-defined westward trades sandwich the calm belt north and south. The "horse latitudes" or tropical calms with their liability to squalls run along the poleward sides of the trades, and beyond them are the "prevailing westerlies" drifting the clouds and storms ever eastward and urging along the ocean currents which later gyrate into the path of the trades and move westward over the equatorial oceans.

A chart of the rainfall of the world, looked at broadly, will reveal correspondingly east-west belts, more or less discontinuous, it is true, but yet discernible. Along equatorial lowlands are the damp, stuffy air and the heavy afternoon rains. Poleward a few degrees in the tropical calm belts in general the rain diminishes and the desert belts are inevitable. The Death Valley, Sahara and Arabian and Persian deserts find their east-west belt of counterparts in the Atacama, Patagonia, Kalahari, and Australian deserts of the southern hemisphere. Poleward from the deserts are the moderate temperate rainfall zones, and flanking these the cold, arid polar regions where the precipitation is snow rather than rain. Even the clouds are arranged in east-west belts and the references to the blue skies of the desert and the gray clouds of the cool temperate apply to most places eastward around the earth. All these different factors of light, temperature, wind, cloud, humidity and rain are climatic ele-

ments, and for this reason there may be distinguished different varieties or realms of climate, which are in broader aspects arranged in east-west belts. Unaccommodating seas and mountains cut across them at high angles and disturb their continuity and make it difficult for us to trace them without some attention, yet the broken and somewhat detached portions show plainly on colored charts the expected east-west zonation.

Vegetation in its broader aspects, overlooking local disturbances, adapts itself to the different sorts of climate, and as a consequence there arise vegetation realms, which, as a colored world chart will show, run in the same direction as the zones of climate. To gather bananas and rubber or to wander in dark, dense, tangled and humid evergreen forests one must, with a few exceptions, stay within the vicinity of the equator. To raise barley and wheat the farmer finds his best opportunities in lands far from the equatorial regions. The cool grasslands of North America, Europe and Asia are in an east-west line and the same is true of the deciduous forests wherein grow elm, ash, oak, maple, and beech. The larch and dwarf willows brave more than any other trees the Arctic cold, and the reindeer lichen, a friend of cool climates only, outstrips other plants in its advance toward the pole.

Animals, too, respond to climate and vegetation. In the tropical forests, where the ground is dark and damp, and the tall trees bear their leaves, flowers and fruit upon the uppermost branches, where the insects and birds assemble in multitudes, nearly all the animals that cannot fly are climbers and spend much of their time in the trees (Wallace). The desert animals have become classic examples of adaptation to a peculiar environment. Upon the grasslands live the cattle, buffalo, bok, antelope, horse, etc. Herding is the chief occupation of Patagonia, S. Africa and S. Australia—an east-west belt of grassland. Had Abraham with his family by chance fallen upon any of these grassland areas he certainly would have been a herder as he was in Syria, for the conditions are practically similar to those of his own chosen land. In the cold pine and deciduous forest the hunter pursues bear, mink, beaver and other fur-bearing animals, and he finds them in east-west belts, for the causes given above.

Man's culture, too, is largely arranged in belts by the rays of the sun about a rotating earth. The primitive equatorial

peoples have made little progress and they are content to live where nature never makes them shiver from unfriendly winter blasts and every banana plant and cocoanut tree, with the slightest cultivation, is waiting to drop its fruit into his mouth when he is hungry. "The bees alone can and do feed him and the honey bird daily guides him to the luxury he craves." Why should he worry about progress? "The struggle for existence that has turned half beasts into whole man has been tempered fatally for him, and in consequence some quality of character, some soul-bone or soul-muscle that the fully upstanding man cannot live without has never been developed" (W. S. Rainsford). The Eskimo is unique and fits his environment. The ambitious, progressive peoples are children of a climate full of extremes, that do not kill, but do with its rhythm of "plenty and dearth" whip them into industry and sharpen their wits to progress.

It may not be possible to teach all this detail to a fifth grade, but the teacher should know the facts for his background, so that he shall be able to follow up the consequences of rotation not only in the lesson but in the entire course in geography. To the pupils the questions should be put concretely, so as to appeal to both imagination and reason, and much will depend upon the devices used by the teacher.

### Rotation and Its Consequences.

The third step is that of teaching the cause of the change of seasons; in other words, the annual rhythm which is experienced by all places on the face of the earth. Some such leading questions as, "Why do we have winter and summer following each other in Indiana?" may be propounded. This question will lead to the statement that summer occurs when the sun is high and winter when it is low. This fact can be located as a result of variation in the slant of the sun's ray during the year. The polar and equatorial condition may also be discussed, although they will add little that is necessary to the conception of the question. Then the query, "Why does the slant of the ray vary through the year?" logically follows. This question appeals for the study of new motions on the part of the earth and it is answered by what is known as the change of seasons. The facts should be put directly to the pupils, with few or no hypothetical cases that do not exist. The facts that the earth travels

around the sun, that the axis is inclined 23½° from a vertical, and that the axis is parallel to itself, or, rather, always points north, should be stated simply as they are and learned. A large globe, as is commonly done, may be carried about a pupil in the center of a circle to illustrate the relations, or four small globes may be set on a table—east, west, north and south of a central object which may serve as the sun. A ruler carried horizontally from the eye of the pupil in the center or from the object serving as the sun to the four globes will represent the vertical ray. Where does the vertical ray fall on June 21, September 22, December 21, March 21? Keep in mind the location of the point on which the vertical ray falls. That is a critical point. Also locate the two north and south tangent rays. Now note as the earth goes around its orbit from March 21 position that the vertical ray moves northward to the Tropic of Cancer. Use a black globe and imagine the sun's vertical ray as tipped with a paint brush or colored chalk. Rotate the globe and trail the chalk, and it will trace a spiral (90+ rotations of the earth) to the Tropic of Cancer. Keeping up the rotation, trail the chalk back to the equator and on south to the Tropic of Capicorn and back to the equator. The pupil sees that one part of the tropical zone after another receives the vertical ray and that while the vertical ray rests on the Tropic of Capricorn the ray on Cancer is very slanting. Tracing the tangent rays, they are seen to play between the pole and a circle 23½° therefrom, and that the slant at the polar circle varies from 0°, when the sun just comes up to the horizon, to 47 when it shines for 24 hours or up to much longer periods. Recalling first the concentric zones that fitted over the earth like a cap, then remembering that when rotation began that the cap was slipped round the earth once a day and the concentric ring-zones came to be belts running east and west, the pupils are now ready to see the final step, that through revolution with the axis inclined and parallel to itself at all times as it is by chance, the belts of temperature are slid alternately north and south. The line on which most sunshine is received on June 21 is the Tropic of Cancer, but it migrates 47° south to the Tropic of Capricorn in the following six months. On the former date the extremity of the tangent ray fell 23½° beyond the north pole and within 23½° of the south pole. Six months later it is reversed and falls as much short of the north pole as it does beyond the south pole.

The entire mechanism of revolution, with inclination and parallelism of the axis, thus results in a north-south shifting of the belts of heat. But not only the heat belts are shifted, the succession of belts discussed above, namely, wind, cloud, rainfall, plant, animal and human, also shift north and south in turn with regular pulsation in response to the migration of the vertical ray. Winter comes to us where once summer held sway. In monsoon lands where winds off the sea brought life to the land, the continental winds blowing toward the sea bring death as the vertical ray plays north and south over the tropical zone. The thermometer in north central North America rises to 80° as the ray grows steeper, but as it declines the mercury hardens to metal that may be bent into finger rings, and great hordes of migratory animals follow pendulum-like northward and southward in its wake.

For any one moment the earth is stationary and the cap covers one half of it with one vertical ray and concentric rings of heat. Rotation shifts this cap continually westward once a day and revolution shifts it northward and southward annually. Always there is the cap, and it is present in three aspects, as a stationary concentric zoned cap (for any moment), as east-west shifting cap (daily), and as north-south shifting cap (yearly). This conception is rather difficult for the pupils of, say, the fifth grade, yet the older pupils can master it. The teacher should know it well. There is a central thought running through the entire problem, and each later stage is seen to grow out of a former as the conditions become more complex. It catches the imagination; it is picturesque since it applies to simple but grand aspects of the earth. It appeals to the reason, for the elements of cause and effect run through it, and system is discovered.

The discussion is not ended, however, until some consequences upon life and culture of this third stage, or revolution, are considered. In contrast to the daily rhythm, as noted above, we have here an annual rhythm that expresses itself in climate and in plants, animal and human life. Summer and winter are the two parts of the rhythm. Summer in our latitude brings the leaves and flowers and fruit of the trees; winter finds the trees bare and brown, and the meadows and flowers covered with drifting snows. Niagara has a different song and aspect for each season. The rhythm of climate and vegetation is less sharply marked in the tropical lands, especially near sea level,

while the contrast is absolute in the polar lands. The tropical plants do not march abreast as they do in our temperate lands where all bud, bloom and ripen their fruit in the same season, but yet each tree experiences a subdued rhythm, having its time for more rapid growth and for the putting forth of leaf and flower. In Arctic lands the plants, as it were, line up and wait in impatient readiness for the first favorable day of the short growing season, and when it arrives, they precociously spring up with incredible rapidity, economizing with short stems and few leaves and extravagantly reveling in a fan-tan of richly colored flowers. For only a few weeks with constant or almost constant sunshine do they hasten to ripen seed and fruit against the coming of the late August frost which leaves them limp and lifeless, and the sport of Arctic winds during the long, dark winter.

The migrations of birds, the hibernation and æstivation of animals, the birth, nurture and growth of the young, the storing of food and many other simple facts reveal the sensitiveness of the animal world to the influence of the angle of the sun's ray. Man's comings and goings are in close harmony with the change of the seasons. The advance of the sun northward sets the reindeer herder on his migration toward the Arctic slopes; it leads Alpine dwellers to climb to the mountain meadows with their cattle, the hordes of the Asiatic grasslands seek the open plains from which the winter storms have driven them. It impels the lumbermen of the north to board the trains in early summer for Texas, and to follow the reaper northward as the increasing sunshine is reflected back in a northward-moving golden wave of ripening wheat, and well-to-do people of our cities seek comfort in the cooler Adirondacks. Man's clothing, diet, diseases; his occupations, and amusements, all mark time to the march of the seasons. "To everything there is a season;" there is "a time to plant and a time to pluck;" a time to produce and a time to store up food and power against the time when these things cannot be done. Forethought is thus enforced by nature as the pulsations of the annual changes impel him to yield to the conditions that they impose upon him.

## THE USE OF QUALITATIVE TESTS OF FOODS IN TEACHING GENERAL CHEMISTRY.[1]

By John C. Olsen,
*Professor of Analytical Chemistry in Polytechnic Institute of Brooklyn, N. Y.*

(*Continued from October number.*)

An illustration of this point is to be found in the introduction of the test for formaldehyde in milk. This is one of the most commonly used preservatives, the test is easily made, and the temptation to introduce it is great. The test, as most of you know, is made by adding to the suspected milk an equal volume of strong sulphuric or hydrochloric acid containing a trace of ferric iron. A violet color is produced on carefully bringing to a boil the sample treated with hydrochloric acid, while the same color is developed by the sulphuric acid without artificial heating. Now, what produces the violet color? The formaldehyde is, of course, partly responsible; but what part does the acid, the ferric iron, or the dozen or more constituents of the milk play? What is the formula of formaldehyde or the purple compound produced? What equation can be written representing the chemical reaction involved? An investigator at the Johns Hopkins University recently endeavored to answer some of these questions and discovered that it was the proteid of the milk which combined with the ferric iron and the formaldehyde to produce the violet color. So that the formula and composition of the proteid of milk must be known to explain this reaction. I imagine that the average high school chemistry teacher would need to spend several weeks of careful study before attempting to answer half of these questions and even then would not care to give his class the chance to quiz him on the subject.

I submit, therefore, the proposition that there are plenty of applications of chemistry to which a simple and satisfactory scientific explanation can be given and that these applications and these only are suitable for presentation to a class in general chemistry. For this reason, many of the qualitative tests of foods are not suitable for this purpose. For the class in domestic science, where the test is an end unto itself, this rule, of course, does not apply.

I have selected a number of tests for foods which involve only simple chemical principles and which therefore seem to be

adapted for use in connection with the course in general chemistry.

A simple experiment involving only the question of solubility in water and alcohol is the testing of lemon extract by diluting a small portion with water. As lemon extract is a solution of lemon oil in alcohol, while this oil like all oils is insoluble in water, dilution produces a milky precipitate consisting of minute globules of oil. Alcohol being the expensive constituent of lemon extract, very dilute spirit is used in the cheap flavoring extract and no oil can be held in solution.

Copper sulphate is used to preserve the green color of peas, beans, spinach, and other green vegetables. The copper combines with the solid portion of the vegetable, producing the green color, while sulphuric acid is formed in the liquid portion according to the following reaction:

$$CuSO_4+2H_2O=Cu(OH)_2+H_2SO_4.$$

In making the test, the liquid is drained away from the solid material. By adding a little hydrochloric acid and barium chloride to the liquid, the well-known precipitate of barium sulphate is obtained.

In order to test for the copper the organic matter of the solid portion must be removed. This is best accomplished by burning it in a porcelain dish. The organic matter first chars and then burns. Both of these phenomena can be explained to the class. Copper as well as copper oxide are non-volatile and remain in the dish and are converted into nitrate by treatment with a little nitric acid and warming. The copper nitrate may then be dissolved out with a little water. As carbon is insoluble in water and nitric acid, it need not be completely burned out, but the charring must be thorough in order to destroy all soluble organic matter. (This reaction is similar to the commercial production of charcoal.) The nitric acid solution may be tested for copper by the addition of ammonia (explain to the class that the blue color is due to the formation of a cuproammonium compound) or by the addition of $K_4FeCy_6$ (red cupric ferrocyanide) or by plating the copper on a piece of platinum by means of the electric current (this interesting phenomenon should be explained). As coppered vegetables are generally so labeled, samples may easily be obtained and all of the reactions given should be explained in the class in general chemistry when copper is studied.

Boric acid is tested for in a similar manner. That is, the organic food material must be burned before the test for boric acid can be made. In this case, the preservative is volatile, as can be easily shown by several simple experiments. The loss of boric acid during the combustion must be prevented. This is done by the addition of lime water. (Explain the use of the strong nonvolatile base in holding the volatile acid.) The thoroughly charred material is extracted with hydrochloric acid and a little water (calcium borate is insoluble in water). The flame test with alcohol, also the turmeric test, may be made for boric acid. In this experiment, the very interesting flame colorations, the wave theory of light, and the probable vibration of the atoms in the gas flame so as to produce definite wave lengths, are explained.

Salted cod or other dried fish is commonly preserved with boric acid, although sometimes benzoic acid is used. The author was surprised recently to find boric acid during the examination of a sample of sun-dried raisins.

Sulphur dioxide is largely used to give color to chopped meats and to bleach vegetables such as canned asparagus, evaporated apples, and other fruits. The detection of sulphur dioxide in foods is carried out as follows: A considerable portion of the chopped food is placed in a flask, water and phosphoric acid being added. The material is distilled, a stream of steam or carbon dioxide being introduced. The condensed vapors are collected and tested for sulphur dioxide. The very characteristic odor is noted. Dilute iodine solution is then added, followed by barium chloride solution. The following reactions take place:

$$SO_2+2H_2O+I_2=H_2SO_4+2HI.$$
$$H_3SO_4+BaCl_2=BaSO_4+2HCl.$$

The separation of the sulphur dioxide is based on the fact that this substance is a gas. Its oxidation by means of iodine and the decolorization of the solution is explained, as well as the precipitation of barium sulphate.

Baking powders are composed in the main of simple inorganic compounds which can be detected by the application of chemical principles which should be understood by the class in general chemistry. All baking powders contain starch and sodium bicarbonate. They differ with respect to the acid constituent, three of which are in common use, namely, alum, calcium acid phosphate and tartaric acid and potassium acid tartrate or cream of

tartar. Baking powders are for this reason classified as alum, phosphate or tartrate powders. The alum powders are the cheapest and the tartrate powders the most expensive.

The first step in the analysis consists in the removal of the starch, which is effected by treating a portion of the powder with cold water. The liberation of the carbon dioxide at this point should be explained. The starch being insoluble in cold water may be filtered off. In order to insure the solution of aluminium hydroxide or calcium phosphate the solution is made acid with hydrochloric acid before filtering. This solution is used for all the subsequent tests.

Neutralize a portion with ammonia. This precipitates aluminium hydroxide or calcium phosphate. Add caustic soda to the precipitate, which dissolves the aluminium hydroxide as sodium aluminate, and filter. Acidify the filtrate with hydrochloric acid and again neutralize with ammonia. A white flocculent precipitate indicates aluminium. By adding barium chloride to another portion of the acid solution, sulphuric acid may be proved by the white precipitate of barium sulphate.

By making a flame test on another portion of the acid solution, potassium may be found by means of the violet color of its flame. It will be necessary to look at this flame through a blue glass in order to exclude the yellow light from the sodium. This is an interesting application of the selective absorption of lights by colored glass.

Aluminium, sulphuric acid and potassium having been found, potash alum has been shown to be present.

The test for calcium can be made on the portion which was used for the test for aluminium, the precipitate which was insoluble in sodium hydroxide being used. This can be dissolved in hydrochloric acid and tested in the flame, or the solution can be neutralized with ammonia and ammonium oxalate added. The white precipitate of calcium oxalate indicates calcium. The acid solution filtered off from the starch may also be used for the flame test for calcium.

The test for phosphoric acid is made by taking a portion of the same acid solution and adding ammonium molybdate and nitric acid. A yellow precipitate which comes down on standing is proof of the presence of phosphoric acid. If this acid and calcium have been found, calcium phosphate was present in the powder.

The test for tartaric acid is made on a fresh portion of the baking powder. Water is added and the starch filtered off. Silver nitrate is added to the concentrated and neutral solution. A white crystalline precipitate of silver tartrate slowly forms. This can be dissolved in a slight excess of ammonia. On placing the test tube in warm water, a bright mirror of metallic silver is formed on the sides of the tube if tartaric acid is present. To get good results the test tube must be absolutely clean. This is a very interesting illustration of the reduction of a metal from a solution and illustrates the commercial methods of making mirrors. If potassium has also been found in the solution, cream of tartar has been shown to be present.

The chemical composition of the constituents of milk is so complicated that the formula and constitution of some of them have not yet been worked out and probably will not be for a good many years to come, although a large number of very able physiological chemists are working on this and related problems. In spite of this fact, it is feasible to carry out some experiments on milk especially during the study of the compounds of carbon. It is very desirable that more experimental work be given during the study of this element whose compounds constitute such a very large portion of our food as well as our bodies. The ordinary manner of dismissing the compounds of carbon by remarking that they belong to the domain of organic chemistry, does not seem at all advisable in view of the fact that not one in a hundred in the class in general chemistry ever gets another chance to take even a peep into this domain. Milk being an ideal food in many ways, its study will be especially profitable for giving the student some conception of the nature of the compounds of carbon.

The relative amounts of water and solids in milk may be shown by evaporating 25 c.c. of milk in a porcelain dish on the water bath. In about one half hour all the moisture will be expelled. The presence of water may be easily shown by placing a watch crystal over the dish for a few minutes. The *percentage* of water and of solids may also be ascertained if the dish is weighed before adding the milk and after expelling the water. Good milk should contain not much less than 13 per cent of solids. The legal limit in New York State is 12 per cent. If 10 per cent of water has been added to the milk, the solids will be 11.7 per cent.

$$[13-(13\times\tfrac{1}{10})=11.7\%]$$

The solid residue consists of fat, casein, sugar and mineral matter. The fat may be removed by adding a few c.c. of ether and stirring with a glass rod so as to dissolve the fat. This solution may then be carefully poured on a watch crystal. By extracting in this manner several times, all of the fat can be extracted and transferred to the watch crystal. When the ether has evaporated, the pure butter fat remains on the watch crystal. By weighing the residue in the porcelain dish, the amount of fat may be obtained by loss. The percentage of fat in the milk should be between 3 and 4, the legal limit being 3 per cent.

The residue in the dish is the casein, sugar, and mineral matter. By heating the dish with the Bunsen burner the casein and sugar decompose and blacken on account of the presence of carbon. On further heating, the carbon burns, leaving an almost white ash. The amount of mineral matter may be obtained by weighing the dish. Pure milk contains very nearly seven tenths per cent of ash or mineral matter.

The ash may be tested for the various mineral constituents present, such as calcium, iron, and phosphoric acid.

The casein and sugar are best separated in pure form from skim milk. About 200 c.c. are taken and warmed to 90° F., and a few drops of rennet or a few c.c. of acetic acid added. This precipitates the casein or curdles the milk, to use a common expression. Casein is acid in its nature and is soluble in alkaline solutions, but is precipitated by acids. The precipitated casein may be separated from the whey by filtering through cheese cloth. It may be washed several times with distilled water, the excess of which is squeezed out. On drying, pure casein or the proteid of the milk is obtained. It contains 16 per cent of nitrogen. The importance of nitrogenous food and its function in nutrition should be explained to the class.

The whey is now made slightly alkaline by adding lime water until red litmus is turned blue. It is then evaporated to about one half the bulk when the albumen generally separates out. This is filtered off and may be dried. It is another nitrogenous constituent of the milk. The whey is then evaporated again to a bulk of about fifteen c.c. On cooling, the milk sugar crystallizes out. It may also be precipitated by adding an equal volume of methyl alcohol and is separated by filtration.

The experiments which have been outlined must be taken merely as suggestions of what may be done toward illustrating the principles of general chemistry by the use of common substances in which pupils are interested. In this manner, the attention is fixed so that new conceptions can be presented and a permanent impression made. I have no doubt that other experiments will occur to the chemistry teacher interested in his work and that the experiments I have outlined may be amplified or improved.

The following books will be found to give not only the complete theoretical discussion of the chemistry involved and the impurities found in the foods, but also instruction for laboratory work.

"The Analysis and Inspection of Foods" by Leach, published by Wiley and Lous, is a very complete work on the subject and should be in the hands of the teacher.

There are three smaller books which are very well suited for the use of students and pupils interested in making these tests. They should be urged to purchase one of these books.

"The Detection of Common Food Adulterants," by Bruce, published by D. Van Nostrand Company, price $1.25, covers the entire range of foods and gives qualitative tests only and was designed for the use of students in preparatory and high schools. Most of the tests given in this book are the best which have been devised.

"The Dairy Laboratory Guide," by Melick, published by the D. Van Nostrand Company, covers the subject of testing of milk and milk products, as well as the manipulation of milk and its products in model dairies very completely. This book is especially adapted for use in schools situated in rural districts.

"Modern Methods of Testing Milk and Milk Products," by Van Slyke, is confined to analytical methods both qualitative and quantitative. It is written for the trained chemist rather than the beginner in the subject, but it may be found useful and of considerable interest in testing or analyzing of milk.

A volume by the author on "Foods and Their Adulteration," which will soon be published by Ginn & Co., contains a considerable number of simple qualitative tests.

## THE VALUE OF CHEMISTRY AS A HIGH SCHOOL SUBJECT.

By J. H. Allen,

*Head of Department of Science, University School for Boys, San Francisco, Cal.*

### To Agriculture.

In investigating the role of chemistry in its various applications to the affairs of human activities we will consider first agriculture, which is perhaps the most important of all, since it is the source from which man first derives his food, shelter, and raiment. This is man's first concern. It is this to which he necessarily must first turn his thoughts and efforts, after which he may pay attention to his temporal and spiritual needs. Therefore if it can be shown that chemistry has aided man in the ease with which he can obtain his food and shelter, or if it can or does conserve those forces or agencies that contribute to these first wants, thus leaving him free for the devotion of more time in developing a higher and better form of life then it seems that we ought by this alone to justify its place in the curriculum, if not indeed raise it from a place of secondary importance to a place in the front rank.

It was in the latter part of the eighteenth century that European countries began to realize that the leadership in the world's industries lay in a liberal education. To this end England founded the South Kensington Institute, which was soon followed by other scientific schools; Germany founded her Real-Schulen and various other technical and agricultural schools, while France also completed a most elaborate school system at a great expense. It is to be noted that these movements occurred as late as the fore part of the nineteenth century. In our own country the situation was also realized, and these movements watched. Our own thinkers had been endeavoring to have something done in this country along similar lines, but our country was yet young and our schools but loosely organized; furthermore a great crisis was approaching and culminated in that great struggle to prove whether a nation "conceived in liberty and dedicated to the proposition that all men are created free and equal" was to continue to exist. However, in this most trying period we had a man in our national congress whose praises should be more widely sung; a man to whom our country owes a debt of undying gratitude it seems to me,

for in a time when the chief concern of our rulers was the raising and equipping of armies, and planning of campaigns; when the results of marches, battles, and expeditions were the sole topic of general thought and conservation; when it seemed that every other interest was merged into that of the outcome of the great strife this nation was fortunate enough to have in the United States Senate a member from Vermont, Mr. Justin S. Morril, who did not lose sight of the plans previously conceived for the government aid of schools in the United States, and who continued to plan and work for it. We all know the Morril Educational Bill which passed in 1862, but I am afraid we fail to appreciate the far-reaching benefits it has been to us as a nation. These results as well as the trying times and circumstances in which the bill was passed is justification for saying that the name and great service rendered this country by Justin S. Morril should be more widely understood and appreciated. There are many who are more or less familiar with the bill, but we wish to refer now to some of its provisions. Perhaps the best known feature is that concerning the setting aside of certain public lands for school purposes, but it is the OBJECTS for which these are set aside to which I wish to call especial attention. It provided that "subjects relating to Agriculture and the mechanics arts" should be "made" leading branches "without excluding other classical and scientific branches," and including "military tactics." In the words of A. D. White,[1] "It was to provide fully for an industrial, scientific, and general education suited to our land and time, an education in which scientific and industrial studies should be knit into its very core, while other studies should also be provided for."

As a result of this bill various agricultural colleges were established, some independently, as Michigan and Iowa, and others as adjuncts to existing institutions as Yale and Dartmouth. These colleges have turned out their thousands of intelligent and trained agriculturalists who have gone forth and been benefactors to man not only in causing two blades of grass to grow where at first was only one, but also by teaching others how to do so. That they are exemplifying the wisdom of the Morril bill and proving the benefits of applying a knowledge of chemistry and biology to agriculture may be observed by

[1] Scientific and Industrial Education in the United States. Andrew D. White. Pop Sci. Mo., vol. 5, p. 173.

the most superficial observer. Witness the improved condition of some of the old New England farms as well as those of the South; think of the advances made in the treatment of the diseases of plants so many of which are of such vital importance to man. Note also the immense proportions to which our department of agriculture has grown, one of if not the largest of our government, then remember that the chemist has filled if not the chief place of importance at least no other branch of science precedes him in all these advances. If we can grasp the significance of all this I think we may see some reasons why our young American agriculturalists should have at least an inkling of this science and hence why we find it in our secondary schools.

The science of agriculture was given a start when Liebig published in 1840 his first work, "The Chemical Process of Vegetable Nutrition, and the Laws of Agriculture." This work contained some false theories, as the author held to the belief that fertilizers should be in the form of insoluble salts of the elements constituting the food of the plant. He eventually discovered by accident his error, and in 1862 republished his work on the basis of this discovery and the science of agriculture has flourished since. Much has been learned as to plant foods or fertilizers, the chemistry of soil and kindred subjects.

Touching the question of fertilizers alone, which we must remember is purely a chemical problem, there are some very interesting facts and figures. We all are aware of the fact that the continued tilling of the soil removes from it what we often call its "strength," but it remained for chemistry to show us what this strength consists of and to what part of the plant it went. Thus in the case of the cotton plant chemistry has shown that the "wool" of the plant and the oil of the seeds are hydrocarbons, that is, consist of hydrogen and carbon, and these we know are not derived from the soil at all, and hence had the former owners known this they could have returned to the soil the remaining portions of the plant which alone had appropriated the ingredients of the soil, and thus have conserved to the soil its virgin strength. I have been told by a very good authority that there is on record a man who has actually done this from the first and who has continually reaped instead of a smaller crop each year a somewhat larger one each succeeding year.

Some idea of the importance of chemistry may be seen by the amount of money which is spent annually for fertilizers. The Southern States spent in 1899 over $22,000,000, the North Atlantic States over $15,000,000 and our own state of California in the same year $937,000 (See 12, U. S. Census Report, vol. V. pt. I pp. cxli), the total expenditures in 1900 in the United States being $54,783,787. By consulting the table of statistics taken from the United States Twelfth Census Report we may see the importance in figures of the crops and industries in which chemistry or chemical processes are more or less concerned. It will be seen thus that the total cotton crop of 1899 in the United States was valued at $517,538,518. Then the sugar and syrup crops which also depend on chemical processes at some point or other were valued at $51,361,685; this includes the beet sugar industry which owes not only the improved plant with its larger percentage of sugar but also the processes of manufacture to chemistry. The value of this branch of the sugar industry was $7,323,857. Of this California's share was $3,499,996.

Table from United States Twelfth Census Report, showing values of farm and animal products—1899:

| Reference | Crop | Value of Crop |
|---|---|---|
| Vol. V. pt. I, p. cxxl | Corn (raw prod.) | $828,258,326 |
| Do | Wheat ( " ) | 369,945,320 |
| Do | Oats ( " ) | 217,098,584 |
| Do | Barley ( " ) | 41,631,762 |
| Do | Total cereal crop | $1,484,231,038 |
| Vol. V. pt. II, p. 324 | Vegetable (raw) | $242,170,148 |
| Vol. V. pt. I, p. cxxi | (Including sugar beets—raw) | 3,323,240 |
| Vol. V. pt. II, p. 478, D | Sugar beets, finished prods. | 7,323,240 |
| Vol. V. pt. II, p. 415 | Cotton (raw) | 517,538,518 |
| Vol. V. pt. II, p. 447 | Sugar, (cane, maple beet, etc.) | 51,361,685 |
| Vol. V. pt. I, p. cxxi | Grand total of all crops (raw) | $3,020,128,531 |
| Vol. V. pt. I, p. cxxi | Value of all animal products | 1,718,990,221 |
| | Value of all agricultural products..... | $4,739,118,752 |

When we remember that fertilization which is a study in chemistry so vitally concerns the crop interests of our country and this in turn the various animal industries; and when we also bear in mind the various ways in which chemical processes

are employed in utilizing these crops for their final finished products and how it is also related to the animal industries, and their products, we can form some estimate of the value of chemistry to agriculture by the consultation of our table on the preceding page. We find that the value of our cereal crop of 1899 was $1,484,231,038. The total value of all crops was $3,020,128,531, while the animal products were valued at $1,718,990,221, making a grand total of almost five billion dollars, a sum almost incredible.

While we cannot get figures to show just what the actual money value of chemistry is to this great field of human activity, yet if they could be had they must doubtless be very great, since chemistry affects it at so many points, and often so vitally.

Although the aid of chemistry is not so much employed in agriculture as in the manufactures, yet it must be so more and more. A comparison of what the agriculturist receives for his products with that which the manufacturer receives for his should be a lesson as to the value of scientific manipulation in any line of work. The farmers' products in 1899 were worth as shown by the preceding table $4,739,118,752, while those of the manufacturer were in 1900 by the tables further on $13,004,400,143. It will be observed that these are for different periods, but I think it will serve the purpose of a rough comparison. I would not be understood as claiming that chemistry is a panacea for every ill, but in this connection it would seem that since the manufacturer uses chemical means to a great profit to himself, why should not the farmer? Of course there are economic and industrial questions back of this large difference in receipts which it is not our place to discuss in this paper. The fact that this is becoming recognized by the farmers of the country more and more is a hopeful sign, not only because of the material benefits, but also for the social and moral significance.

In connection with the advances made along the lines of fertilization and chemistry of soils all sons of California point with pride to the achievements of Professor E. W. Hilgard of the University of California. Mr. H. W. Wiley of the U. S. Department of Agriculture speaking of him and his work says:[2] "In the University of California, the work of Professor E. W. Hilgard must be mentioned as being of fundamental importance in the development of the relations of chemistry to agriculture

[2]The Dignity of Chemistry. H. W. Wiley, U. S. Dept. of Agriculture. Sci. Am. s vol. 53, p. 21,847.

in this country. Professor Hilgard in his classical work on soils has placed himself in the front rank of investigators on this subject not only in this country but in the world, and his achievements have been recognized both by his countrymen and by the most celebrated societies of Europe. A knowledge of the soil and its relation to plant growth constitutes one of the fundamental principles of agricultural chemistry, and the researches of Professor Hilgard in this line have done much to place agriculture in the United States on a strictly scientific basis."

The results that have been obtained in the organic world through chemical agencies have been truly marvelous. Indeed, the renowned achievements of Luther Burbank have gained for him the title of "The Wizard of Horticulture." Of course his success is not all traceable to chemistry; still we do know that plants by proper treatment may be made to develop their different parts to a different degree from that usually found. Thus the sugar beet may be so fed and cultivated as to yield no sugar or only a very small percentage, while on the other hand it may be made to yield very large percentages. Thus Professor Wiley of the Department of Agriculture in Farmer's Bulletin No. 52 gives the following results as found from the analysis of 1,000 pounds of sugar beets showing the composition of roots and leaves, viz.:

| CONSTITUENTS. | ROOTS. | LEAVES. |
|---|---|---|
| Potash | 33.0% | 6.5% |
| Phosphoric acid | .8 | 1.3 |
| Magnesia | .5 | 3.0 |
| Nitrogen | 1.6 | 3.9 |
| Total ash | 7.1 | 18.1 |

Besides showing the composition of root and leaves this table suggests the importance of leaving the leaves on the field. In this same bulletin he gives the best forms of fertilization for the most productive sugar crop, giving mixtures of muriate of potash with potassium sulphate in the ratio of two of the first to one of the latter, or ⅔ potassium sulphate and ⅓ potassium nitrate. Researches along these and similar lines have enabled Germany to free herself of her dependence upon other countries for her supply of sugar.

In the animal kingdom chemistry has rendered a great service, the recent advances made by Professor Loeb being marvelous.

Lavoisier discovered that animal warmth was due to oxidation processes. This has led to the study of foods and food values, and other physiological-chemical processes, and when we try to imagine the far-reaching significance of the results achieved along these lines or try to trace them out and show to what good they have come and how they have benefited mankind our imagination fails us, and our space and time forbid. However, we will try to notice a few. From a knowledge of foods it has been found that animals may be so fed as to make flesh, to grow a wool of a finer texture and more abundantly, or simply so as to maintain life. As to how chemistry affects animal and human life this will be considered in its applications to medicine, sanitation, and such other aspects under another head.

Thus far we have attempted to show the *importance* of agriculture and how *it* depends upon the two sciences, chemistry and biology, and how biology itself has to be supported and its processes improved through chemical means. Thus chemistry is of double importance to the agriculturalist because it increases his efficiency and earning capacity, thus giving him more of the comforts and necessities of life required by the civilized man, and helps him into a position where he may improve himself morally and mentally, for "a man housed like a pig cannot pray like a Christian." Therefore, chemistry is worthy of his study and hence should be well taught in every American school.

### To the Industries.

When we come to look at the part which chemistry plays in the manufacturing industries we are at even a greater loss to appreciate its extent and significance than we were when we tried to imagine its benefits to agriculture. The fact is that it plays one of the most important parts in ALL manufacturing processes, and THE most important part in the majority of cases. Very few people realize this. The average man would see it as obvious that the services of a chemist would be needed in the manufacture of chemicals, but the fact is that his services would be needed less in the manufacture of some chemicals than they would be in places where the layman would never dream that a chemist's services could be of any possible use, as for instance in a silk mill or a flouring mill, the construction office of a railroad company or in a foundry. However, Mr. Carnegie could tell us very differently. He would tell us that it was to the chemical processes for the treatment of iron in smelting and

refining and manufacture of steel which it is said that he himself discovered—though some contradict this—that enabled him to rise from the position of a poor man to that of the owner of the greatest foundries and iron works of this country, and which has made him one of the wealthiest men of the world, which fact should also make him able to be one of the most useful. If chemistry can do so much to advance the material and incidentally the higher interests of one man, why shouldn't it be made to contribute so to all?

That chemistry is of great importance is attested by the fact that experts are employed by the great manufacturers, corporations, and also by the various departments of the government such as that of war, navy, agriculture, etc. Even the patent office employs chemistry in a unique system of indexing. The chemists to the various corporations employing them save annually to their employers vast sums of money not only by directing processes and saving by preventing losses through improper treatment, but they also improve processes and invent new ones whereby a better finished product is obtained, or which enables the process to be carried out more economically. He also often makes discoveries by means of which the waste products are made a source of profit. In fact, although the chemist is not nearly so well paid yet almost always his services have been shown to be of many times the value of that of the attorney to the corporation. Very few American companies sufficiently realize this. However, the case is different in Germany. I have somewhere read where a firm there employed some fifty-six chemists, twenty-three of whom were employed simply in research work along lines of new and economic processes. This is certainly a wise policy from a business standpoint, for once a new process or a new article of use is created it often leads to large and quick returns to the manufacturer, paying him back many times the expense of the discovery, to say nothing of benefits to mankind in general resulting from these new processes or articles of usefulness. In connection with the preceding I quote the report of the Twelfth Census (Vol. x, pp. 527-528) as follows: "In such industrial chemical investigations Germany leads all other countries, and its present preëminence in the field of chemical manufactures has been deservedly won by its work, although it has been materially aided by the character of the patent laws of England and the United States." The German manufacturer is far in advance of those of all other nations in rec-

ognizing the value of specialized chemical skill in the conduct of the works, and in employing trained chemists in laboratory investigations, thus McMurtrie points out that the Fabriken der Actien Gesellschaft Farbwerke, Meister Lucius und Bruning in Hoechst, who were in 1890 making between seventeen and eighteen hundred different colors numbered among their 3,000 employees 70 chemists and 12 engineers. * * *

"Sir Henry Roscoe states that at the German works which he had visited highly trained chemists were employed in original research with a view to new discoveries. One employee who received 1,000 pounds a year without producing any results; but eventually he made a discovery which repaid the firm ten times over, and placed an entirely new branch of manufacture in their hands." These instances suffice to show in a country where the value of the services of the chemist is most recognized by her manufacturers there we find a nation whose manufacturers lead the world in the excellence and cheapness of their products, and who therefore are in a position to control the markets. America has trusted too much to "Yankee genius," as someone has said. This we no doubt do possess but it must in time fall before such superior scientific method as that employed by the plodding German. However, should Yankee genius and German scientific method join hands, the world would see "a pair hard to beat."

As a concrete illustration of what a chemical discovery can be worth to the industries of the world, and in fact to mankind and civilization in general, let us look briefly to what results the discovery of oxygen has led. This element is so well known and its physiological value so generally understood that it has become almost a mere commonplace term, and after all but very few really know of what importance its discovery has been to the advances we have made in our civilization. The discovery of oxygen by Priestly was followed in time by discoveries in the chemistry of flame; it was later found that the oxidizing flame produced a different effect upon iron in its refining to that of the reducing flame. It was also found out that differing qualities of carbon left in the metal gave differing qualities of iron. It was also found that other metals left in the iron gave it various properties, and these questions led to a complex and elaborate chemistry of iron and steel in itself. Through these investigations in which oxygen plays as important a part as the iron itself we have come to have a clearer chemical conception

between iron and steel and processes have been found by means of which it has been possible to so lessen the cost of production of iron and steel that whereas steel rails formerly sold for $200 per ton they may now be had for less than a tenth of that amount. Besides a much better article, although this may be disputed. Thus we see the cheapening of iron and steel traceable back to the discovery of oxygen. Let us look for a moment and see what the value of this fact is. It has made possible our great railroads and their equipment—and what a factor they have been in developing of this country. It has made possible our great bridge and other important engineering feats such as our modern steel and cement fireproof buildings. It has revolutionized our mode of naval defense. It has ushered in the great iron age, in many respects the greatest the world has seen. Who can say to what extent chemical discoveries may yet develop it?

One of the agencies often mentioned by scholars as a very great factor in the revival of learning was the invention of paper and printing. Paper was originally made wholly from rags and old clothing. There came a time when this supply could not meet the demand and the world was threatened with a paper famine but chemistry came to the rescue and taught us how to make good paper out of wood and straw and that at marvelously low prices and thus was rendered to mankind and the world of literature a most important service.

Another very common but important article used by man is sodium bicarbonate or common baking soda. The original process for its manufacture was such as to render it a very expensive article. Now through the improved LeBlanc and the Solvay processes it has become so cheapened as to be a very common and inexpensive article and put to many more uses than would have been possible before. What has been said of iron, paper, and soda might be said of a multitude of other articles indispensable to modern civilized man. Passing from some of these commoner articles which owe their cheapness to improved chemical processes we will consider some articles of less common notice, but still very important. I have chiefly in my mind the bearing of discoveries in organic chemistry. This branch of chemistry has yielded some very remarkable results, particularly in the discovery of methods for making artificial dyes, flavoring extracts, and perfumes. Dying was formerly done from some vegetable or animal coloring matter such as the root of the madder plant for turkey red or of indigo, or tyrian purple from

certain molluscs which when crushed and exposed to the sunlight produced the royal coloring so highly prized by the ancients. Then, too, the cochineal dyes were the bodies of certain insects dried and ground up. Now all this has been supplanted by the artificial products and many more new and varied colors invented. One of the first dyestuffs discovered which supplanted a naturally occurring coloring matter was Alizarin, which supplanted the madder plant. Thus as Professor Cornwall says:[3] "As a result of this artificial madder the world saved in 1880 $20,000,000—more than enough to equip and endow all the laboratories of organic chemistry in the leading universities of the world."

It is an interesting fact that many of these dyes, extracts, and perfumes are extracted from the uninviting, foul-smelling crude petroleum or from the coal tar waste of the gas plants, and whereas it was once the fashion to extract the gas for its own sake and to throw away the tar, now the reverse is practically the case in many places. Germany has the monopoly on the most of these processes. It is stated by Professor Cornwall that in 1893 Germany exported $3,000,000 of Alizarin alone and of coal tar dyes $15,000,000, to say nothing of what she used herself.

We cannot go into detail and give an account of the hundreds of dyestuffs that have been invented and of what an immense service they have been, but we know they have saved the world many millions of dollars each year and have their place in developing the sense of the beautiful and æsthetic in us by placing around us beauty in coloring; in the furnishings of our homes, and in art, as well as advanced the beauty of dress as we can see by comparing the dress of the civilized races with that of the barbaric and savage races.

From the first table we note the value of the products of the industries concerning the metals; thus we see that in 1900 the products of the iron industries were valued at $804,034,918; tin $461,912,619; lead, copper and zinc smelting $358,786,472. The total value of all minerals mined in 1902 was $892,505,617. The total value of all manufactured products of the fifteen different classes of American industries in 1900 was $13,004,400,143.

[3] The World's Debt to Chemistry. Prof. H. B. Cornwall, Princeton. Chaut., vol. 29: 424.

*(To be continued.)*

## SEXUAL HYGIENE.

By A. L. Blackwood, B.S., M.D.,
*Hahnemann Medical College, Chicago.*

"Be honest with the world and the world will be honest with you," forms the opening statement of an address delivered by one of our great statesmen. It is worthy of our careful attention in this connection as it forms the foundation of our social, commercial, moral, and physiological well-being.

The young man or woman who starts life with habits that are at variance with any of these fundamentals must suffer sooner or later. The average school physiology treats the various systems that compose the human organism; with the exception of the organs of generation. This omission is frequently observed in works prepared for the high school.

Instructions in these subjects should form a part of each student's training early in life just as much as the care of the skin, the food tract or any other system. But earlier still; at birth, attention should be devoted to an elongated prepuce of the newborn boy and if such a condition is found to exist it should be relieved that pressure may not be made upon the glands, nor that smegma be allowed to accumulate posterior to the glands and thus become a source of irritation which in some cases forms the initial cause of masturbation. It is also of importance that the girl be examined at this period, as in many cases the clitoris is hooded, and an irritation results, which in various types of nervous disturbance is permanently relieved by the freeing of a hooded clitoris. Many physicians are recognizing this as a subject worthy of careful attention in the preventation of masturbation among girls. This topic has not been as thoroughly considered as its importance demands.

Leaving these topics of infancy we now approach a period extending from the third to the sixth year of life when the child plays in the alleys and other points where he is instructed in the early lessons that result in the promiscuous handling of the genital organs that in time result in a more vicious practice. It is during this period that the mother must be the guardian and shield the child from habits as well as to the watching the position of the hands when the child has retired. When the period has arrived for the child to enter school, another class of influence now surrounds him. Associates come from homes in which the early training has been neglected. Unless careful attention

is devoted to the toilets the child's mind becomes polluted by indecent writing and by allowing the children to tarry in the toilets longer than necessity demands. From a careful inspection of the toilets of many schools the inference is that there is but little difference between the toilets of the boys and those of the girls. And in spite of the janitor's removal of all writing at each recess it would appear again before the next. By a concerted action of the janitor, principal, and head assistant the offender can usually soon be brought to light.

The teaching of sexual hygiene is a subject requiring much tact and attention till the child has passed through the period of adolescence. The importance of the subject is rendered simple if parents fulfill their duties to the child. When this is neglected, nearly every person under whose influence the child may come feels it incumbent upon him to fulfill this task. There are but few who are in any way fitted for the task. In the majority of cases the teacher of biology is the one that should perform the task and if he has the proper attitude there may be no great difficulty encountered. The classes should as a general thing be separated. This should be carried to the extent of not alone having the boy separated from the girl, but men from boys and women from the girls. Sound judgment should be required. Boys should receive instruction such as their period demands, while the boys passing through adolescence and who are beginning to experience the "primordial urge" should have an entirely different instruction. Here the subject of sexual physiology must be gone into with the youth, and by one having the boys' every confidence; otherwise harm is done. In this whole subject it should be the biological method of instruction that should be followed rather than the moral. There is afloat in the world a conception that one may through the aid of the gospel avoid the natural consequences of his deeds. How frequently do we hear such a doctrine expounded from the pulpit; of the praise that is bestowed upon those who late in life have been freed from their evil ways. But it is doubtful if the saved life, into which repentance has come, has brought the strange sense of peace desired. It is doubtful if the repentance can ever give him back the calm strength and poise of assured moral mastery, for vice has assuredly left a mark of disease that no amount of peace can renew.

From a consideration of these degrading habits we pass to a consideration of the social plagues. It has been contended that

school education is the panacea for wiping out the black plague, but it has not been accomplished in such institutions. The state that introduces compulsory education must assume the responsibility of foster parenthood to the end of safeguarding the children from every contagious and preventable disease communicable at school.

It must be apparent that there is a great field of responsibility open here. Text-books on hygiene, public welfare, inspection of schools omit all reference to syphilis and gonorrhœa. Whether this omission is the result of cowardice or ignorance it is difficult to state, but this fact remains, that one fourth of all cases of venereal diseases are acquired before the subject is twenty-one years of age. The literature upon this whole subject of venereal disease, their extent and method of transmission in the primary and secondary schools, is meager. There is an increase in the death rate due to syphilis in the United States while death rate due to gonorrhœa, as well as the blindness, sterility, lameness, and operations the result of its influence, is not fully determined.

It is during this period of school life that sexual development occurs, that sexual irritability and a false conception of the sexual function arises. It is lamentable that at this important age the schools throw no protection about the child either physically or educationally when most needed. Social diseases are not so much crimes as they are diseases of the mind in children of this age.

A series of leaflets adapted to the age of the child, both boy and girl, is frequently of service, as it can be handed directly to the pupil.[1]

Thorough education is the one great requisite in the eradication of the disease. One fourth of our defectives in our state institutions are there as a result of venereal diseases. About

[1]Such circulars are published by the Spokane Society of Social and Moral Hygiene, Spokane, Wash., and may be secured from the secretary, Dr. J. G. Harbison, 207 Nichols Block, at the following rates: Nos. 1, 2, 3, 4, 6 at 60 cents per hundred; Nos. 5 and 7 at 70 cents per hundred, prepaid.

Circular No. 1—The Need for Education in Sexual Hygiene.

Circular No. 2—A Frank Talk to Boys and Girls about Their Birth. For children from 6 to 10 years of age.

Circular No. 3—A Straight Talk to Boys about Their Birth and Early Boyhood. For boys 10 to 13 years of age.

Circular No. 4—A Plain Talk to Boys about their Physical Development. For boys 13 to 16 years of age.

Circular No. 5—Sexual Hygiene for Young Men.

Circular No. 6—A Plain Talk with Girls about Their Health and Physical Development. For girls 10 years of age and over.

Circular No. 7—Sexual Hygiene for Young Women.

Parents may use Circulars 2, 3, 4 and 6 as proper literature to place in the hands of their children, or they may use them as a basis for personal talks to their children.—Ed.

twenty-five per cent of the blind are the result of gonorrhœa ophthalmia. It costs eleven times as much to educate a blind child as one that can see. Education secured at any cost does not give sight, hearing, or health to innocent victims. It is difficult to state the percentage of venereal cases in the schools. In the prevention of this disease school hygiene, the introduction of drinking fountains, the individual pencil, sponge, the improved toilet facility is of service. The removal of the anterior part of the toilet seat that comes in contact with the genitals is to be commended. The need of a physical examination is needed and will be undertaken in time.

## CATALPA PLANTING AS A FINANCIAL INVESTMENT.

By John P. Brown,
*Carney, Alabama.*

While certain people plant trees for the love of it, others plant as a patriotic duty, and some like myself to demonstrate a great principle, yet the business man, the lumberman, and those whose interest is from a financial standpoint, will only plant forests when they can see a profit in doing so.

Let us take one acre of ground and see what we can make it produce.

We pay $10 for the land; a hundred million acres of excellent land, suitable for timber growing, may be bought at this price in the South.

We prepare this land, plant 900 catalpa trees and cultivate them for three years. The entire cost, including our payment for the land, is considerably less than $50, including interest, taxes, superintendence and labor.

In from six to ten years we are cutting out the surplus trees and selling them for fence posts or mining timbers. We thus remove 600 trees, each of which will make two good fence post or three mine timbers. These we sell at ten cents net each readily. One hundred and twenty dollars is thus received for the waste. And yet we have two hundred trees left upon the land to grow into lumber.

We have paid all the cost of the transaction, principal, interest, taxes, superintendence, and labor, and placed in the bank $70 besides, and yet we have the land with a forest growing.

Let us take one tree to which I can cite in Louisiana planted twenty years ago, never cultivated or cared for. It measures thirty inches diameter at height of ten feet, and will cut a twenty foot saw log, containing 700 feet lumber.

Such lumber as I have in my home to-day will readily bring $50 per 1,000—70 M. or $3,500 as the production of our one acre of timber from an investment of $50 for twenty years.

Were these trees of oak, birch, walnut, hickory, or other hardwoods our investment would be for two hundred years and for our grandchildren's heirs, but with the catalpa, like a modern life insurance policy, it comes to maturity during our lifetime.

There are thousands of trees similar to this one that we mention, scattered throughout the United States.

LONG LEAF PINE 30 YEARS OLD AND A CATALPA 12 YEARS OLD.

# PROBLEM DEPARTMENT.

By E. L. Brown,

*Principal North Side High School, Denver, Colo.*

*Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott St., Denver, Colo.*

## Geometry.

210. *Proposed by W. W. Beman, Ann Arbor, Mich.*

Give a *direct* demonstration of the theorem, If the sum of two opposite sides of a quadrilateral is equal to the sum of the other two sides, the quadrilateral may be circumscribed about a circle.

Note by Proposer.—After giving an indirect demonstration, Chauvenet says: "While admitting the validity of this method, geometers usually prefer the direct method whenever it is applicable. There are, however, propositions such as the preceding of which no direct proof is known, or at least no proof sufficiently simple to be admitted into elementary geometry."

Some thirty odd years ago I read this statement to one of my classes, and the very next day a student brought in a direct demonstration in every way satisfactory, which afterwards appeared in Olney's Geometry.

I. *Solution by H. C. Feemster, York, Neb.*

Let ABCD be a quadrilateral having AD+BC=AB+DC. Let BC be greater than AB or AD. On BC lay off B$x$=AB; on CD, C$y$=C$x$. Then AD=D$y$. Draw A$x$, $xy$, and A$y$. The bisectors of the angles B, C, and D are the perpendicular bisectors of the sides of the triangle A$xy$, and therefore meet in a point. Clearly this point is equidistant from AB, BC, CD, DA.

II. *Solution by A. W. Rich, Worcester, Mass.*

Given a quadrilateral ABCD having AB+CD=AD+BC. Draw AO and DO bisectors of angles A and D respectively, and draw OM, ON, OR perpendicular to AB, DC, and AD, respectively. AM+DN=AD, and therefore BM+CN=BC. Also OM=ON. Place triangle BOM in plane of triangle CON so that OM coincides with ON and B and C are on opposite sides of ON. The triangle thus formed is equal to triangle BOC, having three sides respectively equal. Therefore, OR=OM=ON=OS, where OS is perpendicular to BC. Therefore sides of quadrilateral would be tangent to the circle having O for its center and OM for its radius.

III. *Solution by I. L. Winckler, Cleveland, O., and J. M. Townsend, South Braintree, Mass.*

In the quadrilateral ABCD, let AB+CD=BC+AD.....(1)

Let the bisectors of angles A and B meet at O, and draw OE, OF, OG perpendicular to AB, BC, and AD, respectively. A circle with O as a center and OE as a radius will be tangent to AB, BC, and AD. Draw OH perpendicular to CD

AE=AG, BE=BF.

Adding, and subtracting from (1),

GD+FC=DH+CH .....(2)

Also, $\overline{OG}^2+\overline{GD}^2=\overline{OD}^2=\overline{OH}^2+\overline{DH}^2$.....(3)

and $\overline{OF}^2+\overline{FC}^2=\overline{OC}^2=\overline{OH}^2+\overline{CH}^2$.....(4)

Subtracting (3) from (4),

$\overline{FC}^2-\overline{GD}^2=\overline{CH}^2-\overline{DH}^2$,

or $(FC+GD)\ (FC-GD) = (CH+DH)\ (CH-DH)$.

$\therefore$ From (2) and the last equation,

$FC-GD=CH-DH$ ..... (5)

From (2) and (5),

$GD=DH$.

$\therefore$ $\triangle OGD=\triangle OHD$,

and $OH=OG$.

$\therefore$ the circle tangent to AB, BC and AD is tangent to CD.

$\therefore$ ABCD may be circumscribed about a circle.

IV. *Solution by G. B. M. Zerr, Philadelphia, Pa.*

Let ABCD be a quadrilateral such that $AB+DC=AD+BC$. Bisect the angles A and B, and let the bisectors meet in O. Draw $Oa$, $Ob$, $Oc$ perpendicular to AB, BC, AD, respectively. Then $Oa=Ob=Oc$, and $Ac=Bb=AB$. Hence, $Dc=Cb=DC$.

Bisect the angles D and C and let the bisectors meet in O'. Draw $O'd$, $O'e$, $O'h$ perpendicular to DC, BC, AD, respectively. Then $O'd=O'e=O'h$, and $Dh+Ce=DC=Dc+Cb$.

Now $e$ cannot fall on $Bb$ and $h$ or $Dc$ or $h$ or $Ac$ and $e$ on $Cb$, for in either case $O'e$ would not equal $O'h$. Hence $e$ coincides with $b$ and $h$ coincides with $c$; therefore, O and O' coincide. Hence O is equally distant from AB, BC, CD, DA, respectively, and is the center of a circle tangent to these lines.

[Not a *direct* demonstration.—Ed.]

V. *Solution from Olney's Elements of Geometry, University Edition, Page 260.*

Let ABCD be the quadrilateral. Bisect any two adjacent angles, as A and B, and let these bisectors meet in the point O. Then are the perpendiculars $r$, $r$, $r$ from O upon the sides DA, AB, and BC, equal. Let $p$ be the perpendicular from O upon the side DC. It remains to be shown that $p=r$.

Take $AD'=AD$, and $BC'=BC$, and draw $OD'$ and $OC'$.

Since $DC+AB=AD+BC$, and $C'D'=AB-(AB-AD)-(AB-BC)$, $C'D'=CD$, and the triangles DOC and D'O'C' are equal.

Hence, $p=r$.

211. *Proposed by W. W. Beman, Ann Arbor, Mich.*

Give a *direct* demonstration of the theorem, If the sum of two opposite angles of a quadrilateral is equal to the sum of the other two angles, the quadrilateral may be inscribed in a circle.

I. *Solution by H. C. Feemster, York, Neb.*

Let ABCD be a quadrilateral having $\angle A+\angle C=\angle B+\angle D$.

Let B be greater than A. Draw $Bx$ intersecting AD in $x$, making $\angle ABx=\angle A$. Draw $Cy$ intersecting AD in $y$, making $\angle BCy=\angle CBx$. Then $\angle DCy=\angle D$. Let $Cy$ and $Bx$ intersect in $z$. Now the perpendicular bisectors of BC, CD and AB meet in a common point, since they are the bisectors of the angles of the triangle $xyz$. Clearly this point is equidistant from A, B, C and D.

II. *Solution by A. W. Rich, Worcester, Mass.*

Let ABCD be a quadrilateral having $\angle A+\angle C=\angle B+\angle D$.

Draw OM and ON the perpendicular bisectors of the sides AD and DC respectively, and draw OR and OS perpendicular to the sides BC and AB respectively. Draw OA, OB, OC and OD.

$\angle OAD+\angle OCD=\angle D$. $\therefore$ $\angle OAB+\angle OCB=\angle B$.

Place the triangle OSA so that OA will coincide with OC, A coinciding

with C, and the point S falling upon a point S′, S′ and R being on opposite sides of the line OC. Draw SR and S′R.

∠SOR=∠S′OR. ∴ SR=S′R. ∠BSR=∠CS′R.

∴ △SBR=△S′CR. ∴ SB=S′C=AS.

∴ SO is the perpendicular bisector of AB.

∴ a circle with O as a center and OA as a radius would pass through the points A, B, C and D.

III. *Solution by I. L. Winckler, Cleveland, O.*

If a circle is circumscribed about a triangle, the diameter drawn to one extremity of the base makes with the base an angle equal to the angle at the vertex minus a right angle if the angle at the vertex is obtuse, and if the angle at the vertex is acute the angle which this diameter makes with the base is equal to a right angle minus the angle at the vertex.

Let ABC be a triangle having angle B at the vertex obtuse, and let AE be a diameter. Draw BE. Then ∠ABE is a right angle, and ∠CBE=∠ABC−∠ABE. Also, ∠CAE=∠CBE.

∴ ∠CAE = ∠ABC − a right angle.

Again, let ADC be a triangle with angle D at the vertex acute, and AE a diameter of its circumscribed circle. Draw DE. ∠ADE = a right angle, and ∠CDE=∠ADE−∠ADC. ∠CAE=∠CDE.

∴ ∠CAE=∠ADE−∠ADC.

Let ABCD be a quadrilateral whose opposite angles are supplementary, and suppose ∠B is obtuse and ∴ ∠D acute.

Draw AE making ∠CAE = ∠B − a rt. ∠.

∴ since ∠B=180°−D,

∠CAE=180°−D−90°=90°−D.

Now the circumscribed circle of △ABC has its center on AE and also on the perpendicular bisector of AC. This circle will also pass through D, for by the above ∠CAE=90°−∠D, and the circle circumscribing the △ ADC has its center on AE and also on the perpendicular bisector of AC.

IV. *Solution by the Editor.*

In the given quadrilateral let ∠C be greater than either ∠D or ∠B. Construct ∠DCQ=∠D, and ∠BCS=∠B. Then will ∠SCQ=∠A. Let P be center of circle through B, C and D. Let PQ be perpendicular to CQ, PS to CS, PR to AB, and PT to AD. Draw PD, PC, PB and PA.

Now ∠ABC=∠SCB, by construction; and ∠PBC=∠PCB, since the triangle PBC is isosceles. Hence by subtraction we have ∠PBR=∠PCS. ∴ Right △ PRB = right △ PCS. ∴ PS=PR. Similarly, ∠ADC=∠DCQ, by construction, and ∠PDC=∠PCD, since the △ PDC is isosceles. Hence by subtraction we have ∠TDP=∠PCQ. ∴ Right △ PDT = right △ PCQ. ∴ PT=PQ. ∠SPQ is supplement of ∠SCQ, and ∠TPR is supplement of ∠TAR. Since ∠SCQ=∠TAR, therefore ∠SPQ=∠TPR.

Hence, the quadrilaterals PQCS and PRAT are congruent, and PA=PC. ∴ A is on circle passing through B, C and D.

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## PROBLEMS FOR SOLUTION.

### Algebra.

221. *Proposed by J. L. Riley, Waycross, Ga.*

Show that the product of any four consecutive integers plus one is a perfect square.

### Geometry.

222. A sequel to No. 214. *Proposed by H. E. Trefethen, Kent's Hill, Me.*
The alternate sides of an inscribed quadrilateral intersect in P and in Q. Let M be mid-point of PQ and N foot of perpendicular from center of circle upon PQ. Show (1) that MQ = tangent MT, and (2) that PN·NQ = square of tangent NT'.

### Trigonometry.

223. *Proposed by LeForest McCrosky, Lebam, Wash.*
ABCD represents a field. The length of AB is 295.36 feet; of BC is 379 feet; of CD is 195 feet; of DA is 312 feet. The angle DAB is a right angle. F is some point in DA and E some point in BC. F and E are to be taken at such points that FE will be parallel to AB and that the quadrilateral ABEF will contain one acre. To find the lengths of BE, EF and FA.

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## SMOKY TOPAZ.

Smoky topaz is not topaz at all, but quartz, and is called more properly smoky quartz. The coloring matter is organic, and by heating may be entirely burned out. The presence of smoky quartz, therefore, indicates formation at a low temperature. In the vicinity of Pike's Peak in Colorado, smoky quartz occurs in pockets in a coarse pegmatite. One crystal from this locality measured 4 ft. in length.

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## EXPLOSIBILITY OF COAL DUST.

Coal dust is now generally recognized as an explosive more dangerous and deadly than fire damp. Fire damp gives its own warning—the "cap" in the safety lamp—but coal dust does not attract attention unless it is present in the mine in large quantities. Fire damp is generally local in its occurrence, and in the effect of its explosion, though terrific, is also local; but in a dry mine coal dust is everywhere, and its explosion and combustion may affect miles of rooms and entries and may even destroy structures at the entrance of the mine.

The fact that coal dust is a dangerous explosive was not generally recognized until very recently. After the great explosion in the Pocahontas coal mine, in West Virginia, in 1894, by which 114 men were killed, a committee was appointed by the American Institute of Mining Engineers to determine the cause of the explosion. This committee reported that "no trace of fire damp was discovered" and that "the explosion was due mainly to dust," ignited, perhaps, by a blast. Later explosions, in the West, in mines commonly free from fire damp, were manifestly explosions of coal dust.

Several mine explosions in which fire damp and coal dust united as the explosive agents occurred in the United States between 1900 and 1906, and an appalling series of disasters, involving the loss of more than a thousand lives, occurred in 1907. These explosions awakened wide interest among mining men, and in response to their general demand Congress in 1908 made an appropriation for the investigation of mine accidents, assigning the work to the United States Geological Survey.

## TWO NEW PIECES OF PHYSICAL APPARATUS.

(i) *The determination of the coefficient of increase in pressure of air kept at constant volume.*—A bulb of about 2.5 cm. diameter is blown on the end of a piece of thick-walled glass tube. The latter is then bent twice at right angles, and the open end connected to a three-way tube by means of a piece of india rubber tubing. The limbs of the three-way tube are conveniently about three inches long. At *f* a piece of glass tubing about 80 cm. long is connected to the upright limb by means of rubber tubing. The vertical limb of the three-way tube is bent at right angles and then attached to the bottle *g*, which contains water. The connecting rubber tube is fitted with a pinch-cock at *d*. A tin can serves as a water bath. Attach the rubber tube from a foot bellows to *c*, open the pinch-cock at *d*, and then work the bellows. Water will rise in the two vertical limbs of the three-way tube. Open the pinch-cock until the level of water in each limb is the same. (To do this the apparatus may require to be disconnected at *a*.) Stick a small piece of gummed paper at the water-level at *b*. Work the bellows again, and open the pinch-cock. The water will rise to the top of the long tube at *c* and to *a* in the short limb. When this is attained close the pinch-cock. Observe the temperature of the cold water in the bath, and then commence to heat the water, using the stirrer. The air in the bulb expands and pushes the water down from *a* to *b*, the overflow escaping at *c*. When the level of water reaches *b*, take the temperature of the water in the bath, and measure the height from *b* to *c*. Also find the height of the barometer. The following result was obtained by the apparatus described:

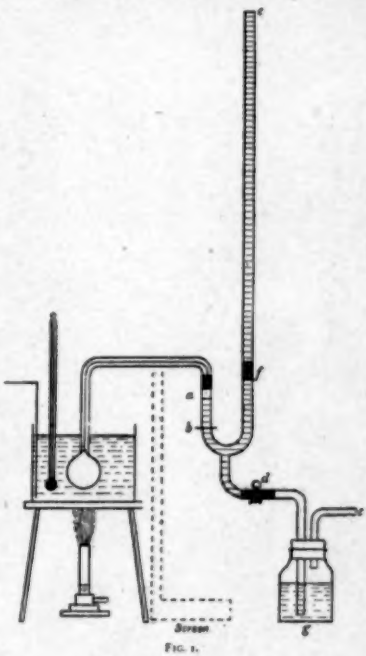


FIG. 1.

Height of barometer = 75.2 cm.
Temperature of water in can at start = 12° C.
" " " finish = 32° C.
Length of water column, *b c* = 75.6 cm.

$$\text{Increase in pressure} = \frac{75.6}{13.6} = 5.56 \text{ cm. mercury.}$$

$$\text{Increase in pressure for } 1^\circ \text{ C.} = \frac{5.56}{(32-12)} = 0.278 \text{ cm.}$$

Pressure at 0° C. $= 75.2 - (12 \times 0.278) = 71.86$ cm.

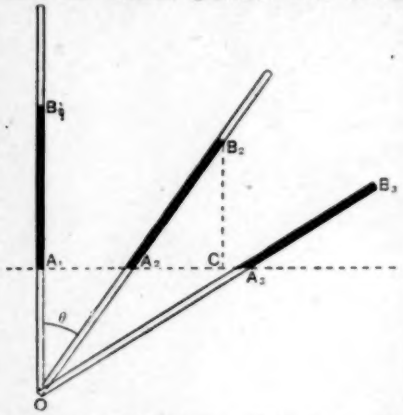
Then coefficient of increase of pressure

$$= \frac{\text{Increase of pressure for } 1^\circ \text{ C.}}{\text{Pressure at } 0^\circ \text{ C.}} = \frac{0.278}{71.86} = 0.0038.$$

There are incidental errors which preclude an exact result being arrived at, but, at the same time, a sufficiently accurate result for elementary work can be obtained, and without the use of mercury.—*School World.*

## A SIMPLE METHOD OF VERIFYING BOYLE'S LAW.

The following method of verifying Boyle's law is, so far as I know, new. Fill a narrow-bore tube with clean, dry mercury. The mercury should be sucked up with the tube in an almost horizontal position. Place the tube in a horizontal position and seal off one end two inches from the end of the mercury, so as to leave no air enclosed at that end. Turn the tube into the vertical position with the sealed end up, and shake the tube cautiously so as to leave about twenty-five inches of mercury in the tube. Clamp the tube in this position, attach a rubber tube and clip to the open end, and suck down the mercury to about seven inches from the open end. Close the clip and seal the tube about an inch from the end. We have now an air space at one end, a thread of mercury about twenty-five inches long, and a fairly long vacuum at the other. We can now investigate Boyle's law without interference of atmospheric pressure. Pivot the end O of the air column at a point O of a squared blackboard. Draw a horizontal straight line through A. On rotating the tube about O it will be found that A travels along the horizontal straight line. In any position the pressure of the mercury is $B_2C$ and the length of the air column $OA_2$. The product of those two will be found to be constant:




This is evident, since $B_2C : A_2B_2 = OA_1 : OA_2$. Therefore $B_2C.OA_2 = A_2B_2.OA_1$, and AB is of constant length.

The readings must, of course, be stopped when the mercury reaches the end of the tube. On this account the vacuum should be left as long as possible. The measurements for a $p$, $v$ graph can be read off direct. If the air enclosed is slightly moist, the curve of A bends slowly upward.

On further experimenting with thick-walled tubes a difficulty has been experienced in sealing through the mercury, owing to the cold mercury cracking the tube. The procedure with a thick-walled tube should be as follows: First draw out one end of the tube to a capillary tube. Fill with mercury and seal the capillary tube through the mercury. Do not attempt at this stage to round off the point. Now complete the tube. Finally, hold the tube with the vacuum up and round off the end.—*School World.*

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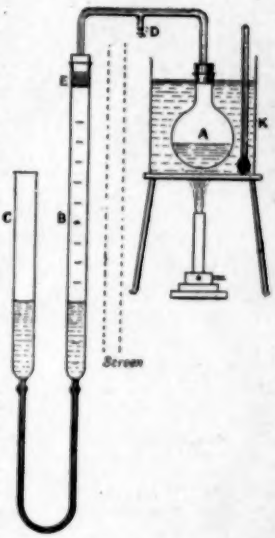
## APPARATUS FOR THE DETERMINATION OF THE COEFFICIENT OF EXPANSION OF AIR.

The flask A, of about 100 c.c. capacity, is fitted with a rubber stopper, through which passes a capillary three-way tube bent twice at right angles. The other end of this tube passes through a rubber stopper which fits in the top of the burette B. The burette is fitted to a leveling vessel C by means of a piece of rubber tubing. E is a wad of cotton-wool. To the limb D of the three-way tube is fitted a short piece of rubber tubing and

pinch-cock. A scratch should be made on the neck of the flask at the point where the bottom of the cork rests when the latter is tightly fitted in. The volume of the flask can then be found once for all by means of a graduated cylinder and water. This volume should be scratched on the flask. Dry the flask carefully and fit in the cork tightly. Arrange a vessel of water K on a tripod so that the flask A is immersed up to the scratch on its neck. Remove the pinch-cock at D and heat the water in the vessel K by means of a Bunsen burner. Bring the level of water in the burette to the lowest division by raising or lowering the leveling vessel C. Allow the water in the vessel K to boil for some minutes, and then take its temperature. Replace the pinch-cock at D and turn off the gas. Replace the vessel of boiling water by a vessel of cold water (at 0° C. if preferred). The air inside the flask A contracts and the level of the water in the burette rises. Bring up the leveling tube C and arrange so that the level of water in each tube is the same. Note if any further rise of water takes place in the bur ette; if not, read off the volume of water and ascertain the temperature of the water in the vessel K. The experiment is quickly performed, and, moreover, the apparatus can be used continuously without any further preparation beyond the adjustment of the level of water in the burette. The following example is worked out from the data of an actual experiment carried out by a student using the apparatus described:




Temperature of hot water = 100° C.
Temperature of cold water = 15° C.
Volume of flask = 93.5 c.c.
1st reading of burette = 50.00 c.c.
2nd reading of burette = 29.50 c.c.

∴ Volume of air entering flask = 20.50 c.c.

93.5 c.c. of air at 100° C. contract to (93.50—20.50)=73 c.c. when cooled through (100—15)=85° C.

73 c.c. of air expand 20.50 c.c. when heated through 85° C.

∴ 73 c.c. of air expand $\frac{20.50}{85}$ when heated through 1° C.

=0.241 c.c.

73 c.c. of air at 15° C. would become 73—(0.241×15)=69.39 c.c. at 0° C.

69.39 c.c. of air at 0° C. expand 0.241 c.c. when heated through 1° C.

∴ 1 c.c. of air at 0° C. expands $\frac{0.241}{69.39}$ c.c. when heated through 1° C.

=0.0035.

—*School World.*

## ARTICLES IN CURRENT MAGAZINES.

*American Forestry* for September: "The Protection of Forests from Fire," Henry S. Graves; "A Forester whose Field is the City," C. D. Mell; "The Reforestation of Denmark," William Hovgaard; "The Karst Reforested"—Two Pictures: "The Story of Manti," Will C. Barnes; "Known by Their Fruits," Edwin A. Start; "The Ninth Annual Meeting of the Society for the Protection of New Hampshire Forests;" "The Philippine Bureau for Forestry and Its Work," W. D. Sterrett.

*Nature-Study Review* for September: Frontispiece—Polyphemus Moth and Cocoon; "Insect Studies," Anna B. Comstock; "Entomology in Secondary Schools," J. W. Folsom; "The Scientific Method in Education Research," W. C. Bagley.

*School World* for October: "The Teaching of Handicraft and Elementary Science in Elementary Schools," by J. G. Legge; "The Examination of Intelligence in Children," (illustrated) by Otto Lipmann; "A Training College Under Canvas," by Mark R. Wright; "The New Regulations for Technical Schools," by James Wilson; "The Home and Education Congress at Brussells," by Emily E. Kyle; "The School Journey: Its Practice and Educational Value," (illustrated) by G. G. Lewis; "The Relation of Science to Industry and Commerce," by R. Blair; "M. Binet's Method for the Measurement of Intelligence," by Katharine L. Johnston; "Outdoor Work for Schools of Normal Type," by J. Eaton Feasey; "School Gardening," by Alex. Sutherland.

*Physical Review* for September: "On the Determination of the Wave-Length and Logarithmic Decrement of the Linear Electrical Oscillator with the Interferometer," James E. Ives; "The Nature of Spark Discharge at Very Small Distances," Elmer H. Williams; "Photographic Photometry and Some Interesting Photographic Phenomena," Charles F. Brush; "Magnetic Properties of Heusler Alloys," Edward B. Stephenson; "Temperature Coefficients of Electrical Resistance. II," Albert A. Somerville; "The Dielectric Constant of Ice, for Long Waves, at Temperatures near the Melting Point," Phillips Thomas; "The Rotary Power of Quartz, Cinnabar, and Nicotine at Low Temperatures," F. A. Molby.

*Popular Astronomy* for October: "Observations of Halley's Comet," Rose O'Halloran; "Schiaparelli," Percival Lowell; "Giovanni Schiaparelli," Hector McPherson; "Leverrier's Letter to Galle and the Discovery of Neptune," T. J. J. See; "Sketches of Jets in the Head of Halley's Comet," H. C. Wilson; "The Swasey Observatory, Granville, O.;" "Note on the Masses of Visual Binary Stars," R. G. Aitken; "The Perseids of 1910," Harlow Shapley; "The Fourth Conference of the International Union for Coöperation in Solar Research," H. C. Wilson.

*Popular Science Monthly* for October: "Address before the National Conservation Congress," President William H. Taft; "The Paleontologic Record: The Relation of Paleobotany to Phylogeny," Professor D. P. Penhallow; "Paleontology and Isolation," Dr. John M. Clarke; "The Role of Hybridization in Plant Breeding," Professor E. M. East; "The Natural History and Physiology of Hibernation," Dr. Allen Cleghorn; "The Home of the Alligator," Professor A. M. Reese; "The Owen Bill for the Establishment of a Federal Department of Health and its Opponents," Dr. Adolphus Knopf; "The Distinction between the Liberal and the Technical in Education," Professor Percy Hughes; "The Tariff Board: Its Scope and Limitations," Seymour Loomis; "A Supreme Court of Science," Professor J. Pease Norton.

*Scientific American* for September 3: "Some Modern Methods of Astronomical Discovery," Henry W. Russell.

*School Review* for October: "Physics and Education," Charles Riborg Mann; "The Relations between Colleges and Secondary Schools: Tendencies and Possibilities," Carleton L. Brownson; "A High School Course in Applied Chemistry," George A. Works.

*Zeitschrift für den Physikalischen und Chemischen Unterricht* for September: "Ueber das Relativitätsprinzip in der modernen Physik," J. Classen; "Ein Galvanometer für Schülerübungen und Nebenapparate," K. Noack; "Versuche zur Zentralbewegung," E. Schulze; "Apparat zur Erzeugung einer Zykloide," W. Pfeifer; "Ueber eine rationelle Temperatureinheit," M. Centnerszwer; "Schulapparat zur elektrolytischen Gewinnung von Wasserstoff oder Sauerstoff," Fr. C. G. Müller.

## OPTICAL PROJECTION.

No better scheme for arousing, focusing, and holding attention has ever been devised than the use of suitable illustrations, and when these are beautiful and artistic and faithful to the subject this method of presentation must be productive of unusually good results.

The recognition of this fact, together with the remarkable progress made during the past decade in the development of the projection lantern, has resulted in greatly widening its sphere of usefulness.

From the amusement field to the hospital clinic is a far cry. The projecting lantern not only does service in both, but fills completely and satisfactorily the gap between.

Its importance in school work is perhaps best attested by the fact that the New York State Education Department has organized a Division of Visual Instruction, and has a collection of 300,000 slides, representing approximately 30,000 subjects, covering the field of school work capable of illustration. Additions to the collection are being constantly made. These slides are loaned free to schools and can be obtained by libraries and study clubs at a nominal rate.

The use of two lanterns, one placed above the other, enables the production of so-called dissolving views, in which one view insensibly fades and blends into the succeeding one.

The microscope attachment is valuable for biological work in schools. A microscope has been devised for this purpose, simple and easy of attachment, which enables the projection of microscopic mounts in a thoroughly satisfactory manner. Thus it is possible to demonstrate to a large class, in a very short time, subjects and material which would otherwise take hours of individual work, if, indeed, with the limited time allotted to the various subjects in the ordinary school curriculum, it could be done at all.

But the field of projection work that is destined, perhaps, to be the most appreciated is opaque projection, whereby an almost unlimited amount of illustrative material can be immediately utilized.

This is done by means of a dark chamber attachment which permits photographs, maps, diagrams, drawings, illustrations from books, natural objects, etc., to be instantly projected without further preparation.

These various methods of projection render the modern scientifically constructed projection lantern a valuable accessory in Sunday School and Church work.

Innumerable series of fine slides are obtainable from dealers; these cover most acceptably the entire range of Sunday School work from Bible history and travels in the Holy Land to the Passion Play at Oberammergau.

For the social side of Church work there is an unlimited supply of material on which to draw. History, art, literature, all the lands of the earth, have been reduced to lantern slide or picture, and can be used in the projecting lantern. Thus the lantern is a never failing source of amusement and profit and should form part of the regular equipment.

A very complete line of projection lanterns particularly adapted for all the purposes herein mentioned is made by the well-known firm of Bausch & Lomb. They range from the simple instrument for lantern slide projection whose price is within the reach of the small church and school, to the elaborate and highly specialized and convertible instrument for university work.

## CEASED TO ISSUE.

*The Journal of Weights and Measures*, a monthly periodical whose first number was issued in November, 1908, after running six months suddenly stopped, having turned its interests over to the *American Beverage and Food Journal*, which for the remainder of the twelve months published its articles, then ceased such publications, the reason for the stoppage evidently being lack of patronage. Such failures as experiments are a hindrance rather than a help to metric reform in the world, and they show little interest is taken in any sort of measuring reform as practice or theory in America, compared, for example, with a country like China. R. P. W.

## DECIMAL COINAGE IN CHINA.

Under date of May 24, 1910, an edict was promulgated establishing decimal coinage throughout China and ordering the stoppage of all coinage by provincial mints. It is, of course, a tremendous move forward and shows that that vast country is going to place itself so far as possible on a commercial level with the foremost countries of the world. Soon it will probably adopt the International System of Weights and Measures, for if decimal coinage is desirable for commercial purposes, why not for measuring and weighing? It would be a grim surprise to many people in the United States to learn that that semi-civilized people, that repudiated nation, was destined to get ahead of America in those greatest instruments of commercial reform, measuring and weighing. Very likely such may be the case. The world awaits the results with interest. Can any reasoning person believe that if China with her coinage reform were also to adopt the metric system of weights and measures, her commercial relations would be injured?

The following are the coins adopted by the great Chinese nation. It will be seen that they are like those of our country: the dollar, 50 cents, 25 cents, 10 cents—all in silver; 5 cents in nickel, and pennies in copper.—[ED. MET. DEPT.]

## IOWA ASSOCIATION OF MATHEMATICS TEACHERS.

The big state meeting will be held at Des Moines November 3-5. A particularly interesting program has been arranged for mathematics and science teachers. Ex-President Roosevelt will address one of the general sessions.

Special attention is called to the program of the mathematics association. This program will be commensurate with the attendance and the occasion. Laura Seals of the Iowa State Teachers College will discuss the graph. This address will be practical and full of usable suggestions. Professor G. W. Myers, head of mathematics, College of Education, Chicago University, will address us on "What Constitutes Adequate Preparation for Teaching Secondary Mathematics."

Whether you are a member of the Iowa Association of Mathematics Teachers or not you are cordially invited to be present. If you are not a member we hope you will become one, which you can do by simply paying the annual dues.

## MISSOURI SOCIETY OF TEACHERS OF MATHEMATICS AND SCIENCE.

The twelfth regular meeting of the Missouri Society of Teachers of Mathematics and Science will be held in St. Joseph, Missouri, in connection with the State Teachers' Association, on November 10 and 11, 1910.

L. D. AMES, *Secretary*, Columbia.

## EDUCATIONAL PRESS ASSOCIATION OF AMERICA.

President, John MacDonald, Topeka, Kan.
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Secretary, J. W. Walker, Indianapolis, Ind.
Treasurer, S. Y. Gillan, Milwaukee, Wis.
Executive Committee: Howard A. Gass, Jefferson City, Mo.; Geo. L. Towne, Lincoln, Neb.

### Members.

American Education, Albany, N. Y.
American Journal of Education, Milwaukee, Wis.
American Primary Teacher, Boston.
American School Board Journal, Milwaukee, Wis.
Arkansas School Journal, Little Rock.
Associat'n Review, Washington, D. C
Canadian Teacher, Toronto, Can.
Colorado School Journal, Denver, Col.
Educator-Journal, Indianapolis, Ind.
Florida School Exponent, Miami, Fla.
Journal of Education, Boston, Mass.
Kintergarten-Primary Magazine, New York City.
Moderator-Topics, Lansing, Mich.
Missouri School Journal, Jefferson City, Mo.
Midland Schools, Des Moines, Iowa.
Mississippi School Journal, Jackson,
Nebraska Teacher, Lincoln, Neb.
New Mexico Journal of Education, Sante Fe, N. M.
North Carolina Journal of Education, Durham, N. C.
Ohio Educational Monthly, Columbus.
Ohio Teacher, Athens, O.
Pennsylvania School Journal, Lancaster, Pa.
Popular Educator, Boston, Mass.
Primary Educator, Boston, Mass.
School and Home Education, Bloomington, Ill.
School Bulletin, Syracuse, N. Y.
School Century, Oak Park, Ill.
School Education, Minneapolis, Minn.
School Journal, New York, N. Y.
School News, Taylorville, Ill.
School Science and Mathematics, Chicago, Ill.
Southern School Journal, Lexington, Ky.
Texas School Journal, Dallas.
Texas School Magazine, Dallas, Tex.
Volta Review, Washington, D. C.
Western School Journal, Topeka, Kan.
Western Teacher, Milwaukee, Wis.
Wisconsin Journal of Education, Madison.

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## LITERARY NOTES.

Henry Holt & Company announce for immediate publication for class reading two well-known German plays: Gutzkow's "Uriel Acosta," edited by S. W. Cutting and A. C. von Noe, of the University of Chicago; and Fulda's "Der Duhmkopf," edited by W. K. Stewart, of Dartmouth. They will have ready at the same time Storm's interesting romance of German student life under the title of "Auf der Universitat," edited, with a vocabulary, by Robert N. Corwin, of Yale. Storm's novel is even more dramatic than the well-known play, "Alt Heidelberg."

Mr. Henry S. Pancoast, in association with Mr. Felix E. Schelling, of the University of Pennsylvania, has prepared a new text-book on the history of English literature which will be published shortly by Henry Holt & Company under the title, "A First Book in English Literature." Though it follows the general plan and chief chronological divisions of Mr. Pancoast's "Introduction to English Literature," it is largely new, written in a simple style, designed for young pupils, and illustrated. It contains less literary criticism and more biography, but otherwise retains the general characteristics of the earlier book.

## PHOSPHATE DEPOSITS IN THE WEST.

The availability of even low-grade phosphate rock for use as a fertilizer gives importance to the enormous phosphate deposits in Idaho, Wyoming, and Utah, many of which are on government land.

The total area of public phosphate lands now withheld from entry is more than two and a half million acres.

Portions of the lands thus withdrawn were examined in 1909 by geologists of the United States Geological Survey, whose reports have just been published.

The reports discuss the geologic age and relations of the deposits, their origin, and the chemical composition of the rock and are illustrated by maps and geologic sections. The deposits are described and mapped in detail and estimates are given of the available phosphate in the several areas considered.

The phosphate rock is chiefly of oolitic structure—that is, it consists of masses of round grains closely cemented together with other material, general calcite. These grains differ greatly in size in each mass of rock, ranging from microscopic pellets to pebble-like bodies half an inch in diameter. Chips of shells and small fragments of plants are in places included in the rock.

The rock at different places differs in color, ranging from gray to jet black, the darker shades being probably due to the presence of bituminous matter.

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## AMMONIUM NITRATE EXPLOSIVES.

Both potassium nitrate and sodium nitrate are used in the manufacture of explosives. In recent years another nitrate, formed by the union of ammonia with nitric acid, and known as ammonium nitrate, has come to be somewhat largely used. It has been used in this country for more than a quarter of a century in the manufacture of some dynamites, taking the place of sodium nitrate and having the advantage over it that on explosion it goes completely into gases; but it has come to be used in Europe in the manufacture of special explosives for use in coal mines, for the reason that on explosion it forms a large amount of water, and this lowers the temperature of all the products of the explosion. In the making of several of these ammonium-nitrate powders, various substances obtained from coal tar, which generally have been acted upon by nitric acid, are mixed with the ammonium nitrate.

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## CHINESE VERMILION.

Ever since Hongkong was established the industry of vermilion-making has been important, according to a report by Vice-consul General Stuart J. Fuller. The manufacture of this pigment is among the foremost of the colony's industries. There are something like 100 small plants for the manufacture of vermilion in Hongkong and Kowloon. The raw material comes from Australia, and the vermilion is prepared altogether by what is known as the wet method. The Chinese made artificial cinabar long before Europe was a civilized country, and to this day there are trade secrets in the vermilion industry which no European has yet been able to fathom. Some of the granite stones between which the pulverized ore is ground are almost prehistoric.

## BOOKS RECEIVED.

Essentials of Chemistry, Experimental, Descriptive, Theoretical. By Rufus Phillips Williams, Instructor in Chemistry in the English High School, Boston, Mass. 8vo, cloth, 421 pages, list price, $1.25.

Wentworth's Plane Geometry, Revised. By George Wentworth and David Eugene Smith. 12mo, cloth, 287 pages, illustrated, 80 cents.

Meier's Animal Study. By W. H. D. Meier. Portfolio containing 36 animal studies, with space for drawings, 16 extra drawing sheets, and 36 note sheets, ruled on book sides. Price, 75 cents. Ginn & Co., Boston, New York, Chicago.

Text-book of Elementary Zoölogy. By Thomas W. Galloway, James Millikin University. 160 illustrations. pp. xx+418. $1.25 net. P. Blakiston's Sons & Co., Philadelphia.

A Text-book of Physics for Secondary Schools. By Charles Riborg Mann, University of Chicago, and George Ransom Twiss, Inspector of High Schools for Ohio State University. Revised Edition, cloth 8vo. $1.25. Scott, Foresman and Company, 378 Wabash Avenue, Chicago; 37 East 28th Street, New York.

Syllabus for Secondary Schools. 481 pages. Published by the University of the State of New York, Albany.

Annual Report of the Cleveland Public Schools. 134 pages. Published by Cleveland Board of Education.

Principles of Secondary Education. By Charles De Garmo. Pp. 212. 1910. The Macmillan Co. Price, $1.00 net.

Botany for High Schools. By G. F. Atkinson. Pp. 494. 1910. Henry Holt & Co.

Practical Algebra. First Year Course. By Jas. V. Collins. Pp. 301. 1910. American Book Co. Price, 85 cents.

Secondary School Mathematics. By R. L. Short and W. H. Elson. Book I. Pp. 182. 1910. D. C. Heath & Co., Boston. Price, $1.00.

College Algebra. By S. C. Davisson. Pp. 243. 1910. Macmillan Company, New York. Price, $1.50.

Elementary Arithmetic. By DeForest A. Preston and Edward L. Stevens. 1910. Pp. 243. The Macmillan Company, New York. Price, 35 cents.

Ornamental Shrubs of the United States. (Hardy, Cultivated.) By A. C. Apgar. Pp. 352. 1910. American Book Company.

Manual of Agriculture for Secondary Schools. By D. O. Barto, College of Agriculture, University of Illinois. With Introduction by E. Davenport, Dean of the College of Agriculture, University of Illinois. Cloth. 104 pages. Introduction price, 50 cents.

Familiar Wild Animals. By Silas A. Lottridge. Illustrated. Pp. 115. 1906. Henry Holt & Co.

A Text-book of Organic Chemistry. A. F. Holleman. Edited by A. Jamieson Walker and Owen E. Mott. Third English Edition, partly rewritten. Pp. 599. 1910. John Wiley & Sons, New York. Price. $2.50.

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## BOOK REVIEWS.

*Methods of Attracting Birds, by Gilbert H. Trofton, Supervisor of Nature-Study, Passaic, N. J.* Pages XV+171. 13x20 cm. Illustrated. $1.25, net. Houghton, Mifflin Co., Boston.

This splendid book comes from the press just in the nick of time. Folks interested in attracting birds to their own particular locality have been using methods which in many cases have not been very successful. This

book puts into compact form for practical use many different ways by means of which different birds may be attracted to a particular locality. In the volume many kinds of bird houses are described, as well as some of the many ways of feeding birds, especially in winter when bird food out-of-doors is scarce. The book was written from two viewpoints, the protection of birds and the pleasure they afford folks. The author has drawn upon many sources for the matter which the book contains. It is therefore rendered much more valuable. It contains seven chapters under the following heads: The Need and Value of Attracting Birds. Nesting Birds. Attracting the Winter Birds. Drinking and Bathing Fountains. Planting Trees, Shrubs and Vines. Bird-protection in Schools. Bird Photography. There is a complete index. The work mechanically is well done; type large, making the book easy to read. It should be in every biology teacher's library, as well as in that of every elementary and secondary school. C. H. S.

*Handbook of Composition: A Compendium of Rules Regarding Good English, Grammer, Sentence Structure, Paragraphing, Arrangement, Punctuation, Spelling, Essay Writing and Letter Writing. By Edwin C. Wooley.* 1909. Pp. 239. D. C. Heath & Co.

This little compendium is for composition as Robert's Rules of Order is for parliamentary practice, a complete authority. It is the most original production in the field of text-books of composition that has appeared for many years. It is the best attempt at codifying the best practice and rules of composition that has ever been made. The exercises are admirably full and suggestive, and excellently adapted to their purposes. In purely mechanical matters, which are the groundwork of all composition study, no other books are half so complete and satisfactory; the author has been remarkably successful in collecting all that is most needed by student and teacher in this field. C. M. T.

*Principles of Secondary Education, by Charles De Ganno, Cornell University.* x+213 pages. 14×19 cm. Cloth, $1.00 net. The Macmillan Company, 66 5th Ave., New York.

A helpful book for teachers, and an interesting one for all professional people and those interested in the science of education to read and study. It is written apparently to show the importance and educational value of ethical training of the youth upon his understanding of knowledge which he may gather from books or teachers. The one thought pervading the whole book is that all of the agencies for ethical training now at work in the secondary schools may be completely utilized. The first two chapters show that through ethical training moral character is made to be a strong corrective agent especially to the young.

Questions for discussion are thickly distributed throughout the work. This is a valuable feature. A complete index is given, the type is clear and large, making the book one easy to read. C. H. S.

*Advanced Algebra and Trigonometry, by W. C. Brenke, Ph. D., Associate Professor of Mathematics in the University of Nebraska.* Pp. 345. $2.00. 1910. The Century Co.

These two subjects are treated in a single book with a fair degree of correlation. It is a good beginning of the close correlation of college algebra, trigonometry, analytic geometry, and calculus. Considerable stress is laid on graphical methods. The slope of the tangent of a curve at any point is found by the derivative method, and Maclaurin's formula is derived and used in obtaining several standard expansions. The chapter on computation, approximations, differences and interpolation is excellent. The topics in college algebra are well chosen and they give the students facts and concepts which will be useful in the applications of mathematics.

H. E. C.

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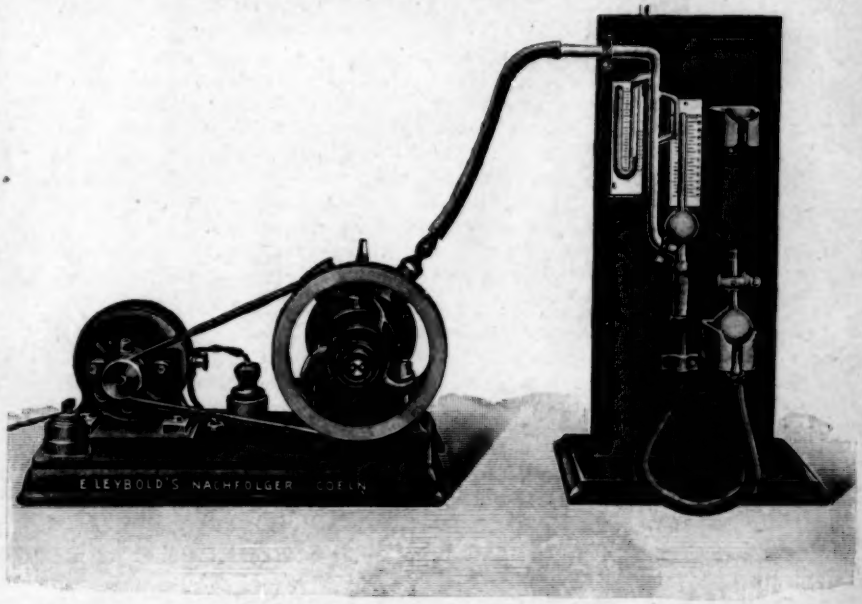


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*Shop Problems in Mathematics, by W. E. Breckenridge, S. F. Mersereau, and C. F. Moore, Chairmen of the Departments of Mathematics, Woodworking, and Metal Work, respectively, in the Stuyvesant High School, New York City.* Pp. 280. 1910. Ginn and Company.

This book is evidently planned to be used in close connection with shop work in any school, and may be used in the mathematics class room or in the shop, or in both. The purpose of the book is to give the pupils information concerning shops and shop materials, and the names of the parts of machines used in wood working and metal working; and to combine with this information a training in the mathematical operations required in shop practice. The problems are largely arithmetical; there is some mensuration and four pages of angle-functions.

Chapters I to XII are as follows: Board measure; House building, general construction, heights of trees and other measurements; Pulleys, belts, and speeds; Areas, volumes, and weights of solids, turned work; Pattern making and foundry work, weights of castings from weights of patterns; Length of stock for forgings, strength of forgings, allowance for shrink fits; Speeds of pulleys, shafts, and gears; Cutting speed and feed; Micrometer, vernier, and tapers; Thread proportions, gearing for screw cutting, indexing; Gear proportions and spirals; The universal grinder and the gas engine. Chapters XIII to XX contain problems for drill in abstract work to develop speed and accuracy in computation.

This book will certainly find a place in many trade and manual training schools. It is well printed and abundantly supplied with excellent drawings and pictures of machines. H. E. C.

*Physics, by Charles Riborg Mann and George Ransom Twiss, Revised Edition.* 424 pp. 13x19 cm. Scott, Foresman & Co., Chicago, 1910.

In 1905 appeared the first edition of the Mann and Twiss Physics.

It was a decided innovation in that it departed markedly from the beaten path in the presentation of the subject.

The 1910 book is more than a revision of the text issued by the authors five years ago. It has been entirely rewritten and is in fact a new book.

The text is divided into two parts, the more difficult and less essential topics being reserved for the second part.

Extracts from the preface will indicate the plan of treatment of the subject.

"Practically no use is made of algebraic formulas in Part I. Symbols are omitted because it is important that the pupils' intuitive notions be crystallized in physical concepts before they are reduced to symbols." "The questions and problems at the ends of the chapters are real physical problems and their solution depends on the use of physical concepts and principles, rather than on mere mechanical substitution in a formula."

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Instead of beginning with definitions and principles, with examples and illustrations appended, each chapter takes up some general problem or observations of the workings of nature and after a discussion of illustrations and examples from the experience of the student leads up to a concrete statement of the principle involved, which serves as a solution of the problem previously stated to the pupil.

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This method of "problem solving" as a method of emphasizing physical principles is frequently used. It is justified by the authors on the ground that it introduces physical principles at a time when a need for them is felt by the student and further that it tends to develop in the student the scientific attitude, i. e., the problem solving and problem stating habit of thought.

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W. E. T.

*Trees of the Northern United States, by Austin Craig Apgar, Professor of Botany in the New Jersey State Normal School.* Pp. 224. American Book Company. New York, Cincinnati, Chicago. 1892.

*Birds of the United States East of the Rocky Mountains. A Manual for the identification of species in hand or in the bush, by Austin Craig Apgar.* Pp. 415. American Book Company. 1898.

*Ornamental Shrubs of the United States (hardy, cultivated), by Austin Craig Apgar.* Pp. 352. American Book Company. 1910.

Everyone who has had occasion to use Professor Apgar's books will regret to hear of his death. Fortunately, he had completed the manuscript of his last book, "Ornamental Shrubs of the United States," on which he had been working for several years, leaving it in such condition that his daughter, who had worked with him on the book, could edit and publish it. It seems worth while to review the whole series now that it is completed by this latest addition.

The books are all of one type in general plan, intended primarily to point the way to the name of the tree or bird or shrub, rather than to give much information. But there is still much well chosen information stated in a very compact and lucid way. There are keys for the determination of genera and species wherever such keys will be helpful. In the bird book two sets of keys are given, for the bird in hand and for the bird in the field. There are numerous very helpful drawings which are a great aid in determining species. In fact the illustrations are one of the most valuable features of the books. In the shrub book there are 615 figures, while in the bird book there are many times this number, numerous small cuts being made use of freely to illustrate or explain the meaning of the text especially in the keys.

In spite of the large number of species described and the free use of illustrations the books are compact and handy in size as such reference books should be. The latest book on ornamental shrubs will be especially desirable on this account, because of the lack of handy sized illustrated books in this line.

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three books deserve to be highly commended, and it is hoped that someone will write a similar book for our spring and autumn flowers for the use of secondary schools. W. W.

*Physiology and Hygiene for Secondary Schools, by Francis M. Walters, A.M., Professor of Physiology, State Normal School, Warrensburg, Mo.* Pp. viii+424. D. C. Heath & Co. Boston. 1909.

Of the making of physiologies there seems to be no end. There are many excellent books in the market, yet new ones are poured in upon us. In the present case the reviewer can find no apparent reason, upon a careful examination, for its being added to the long list of physiologies which precede it. The book is carefully written, and the statements are clear, but its methods are not new, neither is the matter. While, according to the title page, it is written for secondary schools, it is the opinion of the reviewer that the book is much too heavy for classes below the third or fourth year of the high school. It is written in clear, scientific style, but too compact and technical in treatment for immature minds.

Hygiene and sanitation, especially as to diseases, and care for a healthy body have received scant attention. While as the author says a knowledge of the body is essential to the understanding of hygiene and sanitation, yet this is no reason for slighting these topics. For students of high school age they are the real reason for the study of physiology and should have corresponding attention in any book written for high school use. For normal schools and the upper grades of high schools where a course in pure physiology is wanted, the present work is good and can be highly recommended, but it is not suited to the first year of the high school, neither in style nor in subject matter. W. W.

*Industrial and Commercial Geography. By Charles Morris.* 316 pages, 31 chapters, and numerous plates. 1910. J. B. Lippincott.

This is a secondary school text which is well adapted to the first year geography work in the commercial or general English course. For the manual training or technical high school the work outlined in this book constitutes the best course that has been published. This work is essentially a commercial geography in which some slight emphasis is placed upon physical factors but the major portion is devoted to industries and commerce. It is a surprise that the excellent plates are not given better titles. The lack of a good physical and political map of the United States is a decided hindrance to the student. References at the end of the chapters would be a valuable addition. Diagrams could better present the comparative productions of countries than the written statements.

The thirty-one chapters are well arranged and very clearly written. The first six chapters discuss the general principles of industry and commerce involved in man's relation to the earth. The statements are very simple and too much is frequently left to be implied by the student. The idea of physical geography as stated in the opening paragraph is not the modern one. The general summary of man's occupation of the various continents is well stated in Chapter II, which recognizes the controlling factors of climate and soil in the brief treatment of each country.

The physical, industrial, and commercial aspect of the United States forms the contents of Chapters VII-XVII inclusive. In the climatic features of the United States there is no reference to the cyclonic areas which are of vital importance to the activities of the people. The brief description of the physical regions of the United States conveys general ideas which in some cases need revision, i. e.; In the reference to the Colorado Plateau as including most of Colorado and of Columbian for the Columbia Plateau.